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NOTES ON INDUCTIVE LOGIC

(BOOK I)

BEING AN

INTRODUCTION TO MILL'S SYSTEM OF LOGIC.

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PREFACE.

THE following Lectures contain an easy exposition of the chief topics of Logical Doctrine. Although primarily designed for the use of students preparing for University Examinations, yet it is hoped they may prove not uninteresting to the general reader. In the first part of the work there are explanations of notions and terms which were once specialized technicalities of logical science, but which are now so interwoven with current modes of thought and expression that a familiarity with their meaning is an indispensable part of all literary training.

Lectures 7 and 8 will afford the enquirer sufficient insight into the Syllogistic process to enable him after a little practice to sift and test the assumptions, assertions, and arguments of reasoned discourse: a very valuable accomplishment in this age of easy credulity and easy incredulity.

Part II. is devoted to the examination of the principles upon which are based the Experimental Methods of Induction. These Methods are worthy of careful study since they constitute the rational procedure of all Experience, and the Logic of Facts. Although Mr Mill's treatment of this subject is profound and exhaustive, it is not free from certain ambiguities and inconsistencies apt to embarrass the beginner. These it has been the endeavour of the author to remove, chiefly by a more accurate definition of the sphere of Causal Induction. The subject of Quantitative Induction or Theory of Probability is not touched upon, as it has been so recently and ably handled by other writers. The limits of the present volume have also precluded much notice of the Comparative Method of research, so largely employed in many branches of Modern Science. The scope of this work will be completed in a subsequent publication, dealing with the causes and remedies of Intellectual Error: an expansion of the topic usually discussed in Logical works under the designation of Fallacies.

CAMBRIDGE,
December, 1884.

NOTES ON INDUCTIVE LOGIC.

HISTORICAL RETROSPECT.

THE systematic treatment of Logic as a branch of Philosophy seems to have been undertaken by the Greeks, partly for the purpose of discovering a Criterion of Truth, and partly with a view of formulating the principles upon which depends the Art of Rhetoric or Persuasion. Both these aims are discernible in every subsequent development of logical doctrine, and the influence of each is even now apparent in the divergent opinions held by modern writers on the scope and sphere of Logical enquiry. The search after the Criterion of Truth was a direct result of the sceptical crisis which marked the commencement of the middle or Socratic Era of Greek Philosophy—towards the close of the fifth century B.C. Men awoke to a new life of intellectual consciousness when they first became aware of the inevitable and impassable gulf which was fixed between the Subjective and Objective—when Democritus averred that colour, odour, flavour were only states of the percipient mind,—and when Protagoras declared that man was a factor of all his knowledge*. The earlier philosophers had looked forth on the panorama of nature without suspecting that the view was intercepted by their own shadow. Nature was to them a reality, not a picture, still less a mirror. We know not how the consciousness arose of a conflict between the deliverances of the senses, and the verdict of reason,—that things were not what they seemed. It is probable, however, that the advance made in the Science of Mathematics under Pythagoras and his followers was mainly instrumental in emphasizing the discrepancy between the objects of thought and the impressions of sense. The definitions and data of Geometry, the point, the line, the circle, could only be contemplated in their rigid precision and absolute generality as intellectual entities, of which the diagrams appealing to the senses were but imperfect imitations. Which then was to be considered the type of the real, the true? The *imperfect* triangle presented to the eye of sense, or the *perfect* triangle apprehensible only through a definition expressed in language? We find this opposition between the ideal and the actual,—between the abstract and the concrete,—between the one and the many, soon dividing Greek thinkers into two great camps, those who upheld the paramount authority of reason as the criterion of truth against the speciousness of the fleeting impressions of sense,—and those who maintained that the senses were the *only* vehicles of trustworthy knowledge and that reason was but the interpreter of sensuous experience.

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* The idea of the Subjectivity or the Relativity of knowledge seems to have been present to the primitive Aryan Consciousness, for we find it expressed in the quaint Sanscrit proverb: "Is not the whole world covered with leather to him whose foot is covered with a shoe?"

In this controversy both sides appear to have appreciated the use of logical artifices as weapons of attack and defence, and the effect of such polemics must undoubtedly have been to direct attention to the nature of evidence and proof:—to encourage the habit of analyzing the operations of the understanding in the pursuit of truth, and above all to show the necessity of conducting speculative enquiry according to some established rules of rational procedure. We see the evolution of this logical consciousness in the teaching of Socrates and the writings of Plato. The object of the Socratic or *maieutic* method of teaching was to elicit by the processes of definition and induction the truth which was supposed to be latent in the minds of the hearers. The dialectic of Plato was intended to discover the archetypal ideas embodied in things. Both maieutic and dialectic are examples of attempts to prosecute philosophical enquiry in an orderly and systematic manner.

We can understand, then, how an examination of the processes of Ratiocination would recommend itself to the Greek mind as an aid in Physical and Metaphysical research; but we also find the enquiry into the principles of inference and demonstration emerging as a science of Rhetoric or Persuasion. Many of the states of Greece enjoyed a popular form of government under which the will of the people could be freely expressed in representative assemblies. At such conclaves the ablest debater would soon come to be regarded as the ablest statesman, and would obtain the greatest amount of power and reputation in the community. Hence the art of oratory was considered an indispensable requisite in the training of any citizen ambitious of rising to eminence in the State. Again, the ancient Greek was incorrigibly litigious and the law-courts offered abundant opportunities for the exercise of the rhetorical art, so that some of the greatest orators of Greece manifested their power in forensic pleading. In each of these species of oratory, and in the latter especially, the design of the speaker was not so much to expose the truth as to produce an immediate feeling of conviction in the minds of his audience, whatever might be the real claims to belief or acceptance of the matter he was advocating. Hence the business of the Sophist or professional teacher of Rhetoric consisted largely in rendering his pupil expert in the arts of chicane, the coining of ambiguous phrases, the colouring of statements, and the shuffling of premisses. Plato we know dreaded the power by which the worse cause was made to appear the better. Although we do not find in his writings any express analysis of the principles upon which this power depended, yet from the frequent allusions to, and contrast of the *schein* and the *sein* in every art, it seems pretty evident that he perceived the whole secret of sophistical argumentation to consist in the substitution of the FORM for the *Reality* of *Proof.* It therefore became an object of paramount importance for those who would guard themselves against the arts of specious eloquence, which threatened to be equally disastrous to political as well as to personal morality, to study well the mode in which the logical faculty is exercised, and its operations expressed in language. The analysis of the reasoning process in its relation to verbal signs was the task which Aristotle, the disciple of Plato, undertook with so much success that he is universally credited with the honour of having been the first to unfold the laws and rules of logical science. There seems no doubt, indeed, that the doctrine of the Syllogism as the ultimate form of the reasoning process, with its governing principle of the "*dictum de omni et nullo*" was originally enunciated by *Aristotle*, and this is generally recognized as the characterizing feature of the Aristotelian or scholastic Logic. The theory of *rational expression* was unfolded by Aristotle in six separate works. 1. De Interpretatione, which treats of language as the exponent or interpretation of thought. 2. The Categories, which deals with the classification of names or marks. 3 and 4. The Prior and Posterior Analytics, elaborate discussions of the Syllogistic process. 5. The Topics, being an examination of Proof short of demonstration. 6. The Sophistical Refutations, a discourse on Fallacies. These six Treatises were comprised in a single work by one of Aristotle's successors, and entitled the "Organon," but Aristotle himself seems neither to have accepted the term Logic as the distinguishing appellation of the science of ratiocination, nor to have sanctioned the application of the designation Organon to his writings on the subject. Many commentators have thought that the treatises of the Organon are not coherent, and that they contain much matter irrelevant to the subject of Logic as now understood. Writers of the Mansel and Hamilton school, especially, consider that the grammatical and metaphysical matters discussed are entirely alien to the province of logical enquiry. It must be remembered, however, that to the then level of Greek consciousness *the thought*, *the word, and the thing*, were but imperfectly differentiated. This is sufficiently indicated by the ambiguity in meaning of the term "Logos," which may equally signify the word, the thought, and the cause or reason. And it was natural that Aristotle, who only represented the philosophical opinions of the age in which he lived, should be unable to separate Logic from Grammar and Metaphysic. Again Reasoning may be regarded as *the perception of the implication of statements*, which is the view adopted by the modern school of Formal Logicians—or Reasoning may be regarded as the *perception of the implication of matters of fact*—which is the standpoint of Mill and the so-called Material Logicians. But to the ancients of the Platonic mould of thought, of whom Aristotle was assuredly one, the *reason* or *bond* of argument was inextricably blended or identified with the *cause* or *bond* of nature. Hence it would have been impossible for Aristotle to expound the theory of Syllogisms without continual reference to metaphysical assumptions. This will be abundantly manifest from the following extracts translated and cited by Mr Wallace*, from the "Organon," which, however, will be scarcely intelligible to any but Hegelians. "Syllogism and Induction correspond to the two great aspects of existence or ways in which things are known. Things may be looked at either in themselves—as they present themselves, so to speak, to the creative mind—or as they present themselves to us; thus in Mathematics it is the point which stands absolutely first, the superficies or solid figure which is first relatively to us. Syllogism corresponds with the first of these aspects of the object of knowledge—it starts with law or cause, and reasons forward to the application or effect: Induction begins with facts of personal experience and reasons backward to the cause or principle. But knowledge, properly so called, lies in explaining things by reference to what is absolutely prior, and in seeing that their causes lead necessarily to particular effects.* * * The universal, however, is not merely what is common or generally applicable; it is also the essential attribute which holds good of the most rudimentary form in which the generic conception shows itself. So conceived the universal is equivalent to the cause, and this in turn becomes the middle term of a Syllogism. Genuine logical proof then lies in tracing out by syllogistic reasoning the essential attributes attaching to some thing or motion. * * * So far, then, as the cause is represented by the universalizing middle term, the questions of science resolve themselves into a search for middle terms. * * * The question, What is the reason of the fact? and the question, What is its essential nature? constitute a search after the middle term." We see from these extracts how thoroughly the mind of Aristotle was governed by the notion that the *Syllogism of discourse* was commensurate with, and representative of, a corresponding *Syllogism in nature.* We may observe also from these and other passages of Aristotle's logical treatises, a show of Scientific Method which probably procured for the compilation the title of "Organon."

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* *Outlines of the Philosophy of Aristotle*, p. 46.

The converse processes of Deduction and Induction are apparently recognized as well-defined modes of rational procedure. But it is easy to detect wherein the radical defect lay of Aristotle's conception of a fruitbearing mode of investigating the nature of things. A defect which may well have obscured the real paths to knowledge in succeeding ages, till Bacon arose and "scattered the rear of darkness thin." It was not that the Ancients were ignorant of Deduction and Induction, of Synthesis and Analysis, as processes of discovery and verification. What rendered their methods so utterly barren of results was the nature of the material on which they were employed, and the mistaken aims towards which they were directed. What could have been the product of the soundest methods when they were employed in attempting to discover or analyze the ideas in a creative mind, or their universal forms in created objects? The human consciousness was still in the metaphysical stage which Comte declares to be the second great epoch or era in the development of the human intellect. Elsewhere we find Aristotle with sufficient precision and clearness setting forth the manner of research most suitable for the only two non-metaphysical sciences which the Greeks seem to have thought worthy of methodical treatment, viz. Medicine and Morals. In the opening chapter of the Metaphysics Aristotle describes the process of connecting a disease with its remedy by simple experiments in a manner very much like Mill's account of the Method of Agreement, although, curiously enough, the healing art is considered by Mill the very worst field for employment of the Inductive methods of research.

In the latter three centuries of Greek Philosophy before the commencement of the Christian Era, the Stoics and Epicureans continued the cultivation of Logical doctrine on the lines laid down by Aristotle and taught by the Peripatetics*. The Epicureans gave the name of Canonic to the Science, their mode of treatment of which seems to have been not unlike the material Logic of our day—the aim with them being as the name implies the establishment of rules for methodical research. The Stoics are said to have been the first to confer the distinctive title of Logic on the study of the theory of reasoning. Logic they held to be the third part of Philosophy, of which Physic and Ethic were the other two. They illustrated the Architectonic or comprehensive character of logical teaching by the quaint comparison of the whole of Philosophy to an egg, of which Physic was the yolk, Ethic the white, and Logic the shell. With the Stoics indeed Logic was supposed to unfold the principles or framework upon which every kind of theoretical knowledge depended for evidence and demonstration. And in every province of enquiry they took up such an arrogant and dogmatic position that they challenged the attacks of the sceptical sects by whom they were surrounded. Like Locke in modern times, the Stoics allowed no other origin for human knowledge than the impressions of the senses,—and like Locke they were driven into an inevitable *cul de sac*, when they attempted to build any kind of objective or universal truth upon such pure empirical data. The Sceptics had no difficulty in showing that veritable experience was unattainable and therefore could never be accepted as a valid basis for absolute truth. Between Subject and

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* Some historians suppose that the actual writings of Aristotle were not made public until three centuries after the death of their author.

Object there yawned that chasm which the Stoics used all their Logic as a bridge to span, and the Sceptics as a wedge to widen. Round and round a vicious circle, the Sceptics pursued their adversaries, defying them to find a criterion of truth or evidence in the realm of phenomena.

Carneades of the later Academy was the most prominent leader in these attacks on the empirical dogmatism of the Stoics. This philosopher, besides being an invincible disputant, was a very acute thinker. He was the author of the Sorites*, a logical puzzle, deserving more consideration than it has generally obtained. In this toy is embodied the germ of the idea of increase by insensible gradations, an idea which in modern thought has played such an important part in mathematical science, as the principle of finite differences;—and in physical speculations, as the doctrine of development by evolution. Carneades also seems to have been the first to formulate a theory of probability as a valid basis of proof, in lieu of demonstration which he saw was impossible from empirical data; he also seems to have handled the conception of causation apart from metaphysical implications, a considerable advance on the Formal and Final Causes of Aristotle. But the name of Carneades bears an evil reputation from the unscrupulous cynicism with which he employed the resources of Logic in the service of a meretricious Rhetoric. Give me the conclusion, he used to say, and I will find the premisses; and we know how once on an embassy to Italy he shocked the susceptibilities of the unsophisticated citizens of Rome, by delivering an eloquent oration on the beauty of Justice one day and declaiming with equal plausibility against it the next. The era of Greek philosophy closed amidst these endless logomachies about the Criterion of Truth, which we are told divided men into three parties, one which declared that truth was unattainable, another which said it had been attained, and a third which admitted it perhaps might be, but had not yet been grasped*.

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* The idea of the Sorites, however, seems not to have been original to Carneades, as the same principle is found in the Calvus and even in the Tortoise.

There was a temporary revival of Greek speculative activity in Alexandria during the early centuries of Christianity. We find Logic cultivated in its purely formal character by Porphyry and the Neoplatonists. The principle of Dichotomy in formal logical division was enunciated by Porphyry, the chief interest attaching to which arises from the employment of this principle by Boole and Jevons, in our own day, as a law of the reasoning process. A similar theory, however, seems to have been enunciated by Plato, and criticized and rejected by Aristotle (*Pri. Anal.* I. 31). Some of the writings of this period which have come down to us, are highly valuable to the student of the history of Method, on account of the glimpse they afford of the tone and character of the learned world then concentrated in Alexandria. We find six accredited sciences included under the title of Mathematic, viz. Grammar, Rhetoric, Geometry, Arithmetic, Astrology and Music. This list with the addition of Dialectic is evidently the same as the Encyclopaedia of Knowledge or Seven Liberal Arts which formed subsequently the staple of education in the Universities of Western Europe, and which as the Trivium and Quoddrivium constituted the seven years' course of study required for a B.A. or M.A. degree. All these sciences were deductive in method, starting from an array of definitions, axioms and postulates after the manner of Geometry. Sextus Empiricus, a physician, contemporary with Galen about the beginning of the third century A.D., published a treatise containing a sweeping attack on the procedure of each of these sciences; the burden of his charges is the incompetence of the Syllogistic Deduction to establish valid proof. The arguments he employs are much the same as we are familiar with in the writings of Locke and Mill. All purely deductive reasoning can be easily reduced to either a regression to infinity, a *petitio principii*, or a set of unproved assumptions. The inherent weakness of the doctrine of syllogism then taught exposed all systems relying on the deductive method to this kind of onslaught. The syllogism was considered by all good Aristotelians not only as the form but the instrument or organon of proof. No one now-a-days retains this opinion explicitly, and if the works of Sextus Empiricus had not been so long in making their way to western intelligence, it is probable that the labours of Bacon and Locke would have been long anticipated. The Inductive process of reaching first principles is noticed by Sextus, and seems to have been recognized in his time as the method of the empirical school of philosophers. As attacked by him, however, this method appears only to have been that crude and elementary kind of induction based on a bare examination of a number of instances without sifting or verification by experiment. Of course there was no difficulty in showing the inadequacy of such a procedure to yield any valid evidence for the establishment of general laws. You must either, says the critic, generalize from a limited or unlimited number of instances,—if the number be limited the generalization is unwarranted, if the number be unlimited it is impossible to examine all the instances. It seems certain, therefore, that the conception of Induction through experiment was not a distinct element of scientific method at the time of the Alexandrian schools. This fact is important in estimating the real claim of Bacon to the character of a reformer of scientific method.

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* Sextus Empiricus, Hyp. I. I.

With the closing of the academies in Greece by Justinian, and the founding of the cathedral schools by Charlemagne, the intellectual activity of Western Europe entered on a new phase. The influence of the Church moulded the whole system of the education of the learned from this time to the Reformation or Rénaissance. Henceforth it required no inductive process or intuition to discover first principles for demonstration. These were supplied by authority, and hence the only business of Logic was to perfect the syllogistic process of reasoning from admitted premisses. Much of the ancient logical doctrine, however, had to be recast, as the language in which it had been first promulgated was not cultivated by the mediaeval learned. And the real drift of passages from the writings of Aristotle, filtered sometimes through Arabic and Hebrew into Scholastic Latin, furnished endless themes of controversy for the good fathers of the monasteries and universities of the eleventh and twelfth centuries.

The question of Universals as they were termed, or of the real significance of general names was the link by which the continuity of ancient and modern thought was maintained. We are told that an ambiguous expression in Porphyry's introduction to Aristotle's Organon occasioned the revival of the controversy towards the end of the eleventh century by a monk named Roscelin. The import of a general name contains a concrete and an abstract element. It is concrete inasmuch as the name is applied to each of a number of individuals, and it is abstract so far as it expresses a group of resembling attributes. Now the semi-developed intelligence is ever prone to hypostasise abstractions. The Greeks had unconsciously confounded *phenomenal uniformity* with *nonmenal reality*, and supposed the abstract element in common names to stand for some external reality. The Platonists conceived this reality as the archetypal idea in a creative mind,—the Aristotelians as the common or general essence in classes and species. This was the famous doctrine of Realism against which the Conceptualists and Nominalists revolted. The Conceptualists affirmed that the generality in a common name only represented a general idea in the mind of the speaker, while the Nominalists declared that it simply expressed a perception of resemblance between the members of a group of similar objects. This conflict marks the percussion of the obsolescent metaphysic of the East on the nascent Positivism of the West. The ancient Realism or Idealism seemed to have a temporary revival, but the future philosophical consciousness of

Europe was destined to be shaped and coloured to an ever-increasing extent by the influence of Nominalism. However this question belongs rather to the history of Philosophy than of Logic. The golden age of Logic is generally associated with the era of the schoolmen, but it is rather for the practice than the theory of Logic that the scholastic period is famous. With the exception of a few technical expressions and puerile mnemonic lines, little was added to the doctrine either of Form or Method. The authority of Aristotle was paramount during this time, and the philosopher would indeed have been bold who should have dared to tamper in the slightest degree with the opinions of the Stagirite on any point of logical doctrine. But it is remarkable that when the sway of Aristotle was all potent over the intellect of Western Europe, his most ardent disciples had no direct access to the writings of their great master, and that as the study of Greek became introduced into the Universities the authority of the Stagirite began to decline. During the Middle Ages the entire course of intellectual training pursued at the great seats of learning had been in England and on the Continent moulded by the influence of Aristotle. But from the period of the Renaissance the credit of the ancient method continued to wane until Bacon had only to bid Aristotle, as Diogenes had once requested his great pupil Alexander, to desist from intercepting the light.

With the name of Bacon we enter upon the region of modern thought, of which he had a Pisgah view, and which the influence of his genius still irradiates. Bacon's reputation indeed has floated down to us on a flood-tide of material progress, and his fame has risen with the stream that bears it. Comparatively few know or care much about Bacon's contributions to the improvement of Scientific Method, but all can appreciate his vindication of the dignity of Utility in the noble utterance, "The end of learning is the glory of God and the relief of man's estate." The ancient Philosophers had despised the cultivation of those practical Arts upon which so much of the well-being of humanity depends. Absorbed in fruitless efforts to explore the sterile realms of abstraction, they left to unlearned artizans the task of invention and discovery in the appliances of daily life. Bacon brought Philosophy from the academy into the laboratory and workshop,—divorced Science from Metaphysic and wedded her to practical Art. Professor Fowler asserts that Bacon was as much the creator of Inductive logic as Aristotle was of Deductive, and he thinks that the method of Induction by elimination as distinguished from Induction by simple enumeration, is the special discovery of Bacon. Mr Mill indeed has found much to modify in the Baconian employment of Induction, and the Socratic Induction was a method of elimination; still it is no doubt true that to Bacon must be ascribed the merit of first distinctly recognizing the rules and principles which constitute an art of discovery in physical phenomena. The established syllogistic method of Deduction was quite adequate to the requirements of ancient research, where the premisses were assumed and the conclusion unverifiable. But Syllogism could never interpret the ideas of nature, although it might express the thoughts of men. Bacon said that the business of science was to enquire into the forms of simple natures.

By simple natures he appears to have meant those elementary agencies which when combined constitute the properties of objects, as the letters of the alphabet make up the varieties of words. There is some doubt attaching to the meaning of the word Form as employed by Bacon. Professor Fowler, however, seems to show conclusively, that all the different uses of it found in Bacon's writings may be reduced to two, viz.:—essence, or law. In many cases indeed the two significations coalesce, as when Bacon proves that the form of Heat is Motion, it is scarcely distinguishable whether he intends to imply that the cause of heat is motion, or that heat and motion are identical,—two modes of looking at the same phenomenon. Bacon's machinery for collating Inductive evidence is analogous in its form, although totally opposed in its application to the methods analyzed by Mr Mill. But Bacon like many a precursor of thought, has taught more by suggestion than actual performance. His ambiguous application of the term Form indeed points to the suspicion that he was not altogether free from the spell of that ancient metaphysic which he so despised. Bacon's endeavour to formulate a *science* of Method does not seem to have been imitated by the age immediately succeeding him. But many notable examples of new *applications* of Method mark the course of the 17th century. That by Descartes, in his conception of expressing geometrical relations by algebraical symbols,—by Spinoza, who attempted to demonstrate the principles of Ethics like truths of Geometry, and above all by Newton, who depicted the laws of natural phenomena through geometrical curves. But the logical character of these experiments in Method has not been hitherto examined.

Formal Logic was popularized by the Port Royalists towards the end of the 17th century, but purely on the lines of Aristotle. The 3rd and 4th books of Locke's great *Essay on the Human Understanding* are logical in their matter; the 3rd book is a diatribe against the still lingering doctrine of "real essences" as the basis of "class notions." He appears finally to have laid these spectres of ancient ways of thought, and if his work had only contained three books instead of four, the value of Locke's services to philosophy would have been less questionable than it is. In the fourth book he attacks the entire deductive method of reasoning by definitions, axioms and syllogism—but his contention aims at proving too much. Not only is syllogism an illusory mode of rational procedure, but it is not even the correct verbal exponent of the reasoning process. In endeavouring to impugn the syllogism as a valid mode of rational expression, of course Locke cuts away the branch on which he rests. Syllogism is not the natural form of ordinary discourse or debate, but it is the form to which every argument may be reduced, and by accordance with the rules of syllogism, the consistency or conclusiveness of every argument must be ultimately tested. There is no doubt that Locke's authority has mainly tended to throw discredit on the study of Logic during the last century and a half. If formal Logic is an *inadequate* analysis of an *instinctive* process, of course its cultivation is not even valuable as a mental gymnastic. But Locke completely failed to show this. The real core of the question respecting the value of Logic as a means of mental training is that discussed by Dr Whewell and Sir William Hamilton a generation or two ago. Is the development of the logical faculty secured best by strenuous use, or, by accurate analysis? Dr Whewell maintained the former view, and considered that Mathematics afforded sufficient exercise for the rational faculty, while Sir William Hamilton insisted that the ability to analyze a mental operation must facilitate the process. The point remains still undecided, but there are not wanting signs of an awakening interest in logical science. Some recent text-books have reached nine or ten editions. The logical analysis of sentences has become an adjunct to the teaching of English Grammar in all Middle Class schools. From the analysis of sentences it is but a step to the analysis of arguments, which we may therefore hope ere long to find generally taught in schools and Universities.

The student is referred for an exhaustive history of Logic to the work of Professor Prantl.

NOTES ON INDUCTIVE LOGIC.

PART I.

LECTURE I.

INTRODUCTION AND DEFINITION.

1. LOGIC is an eminently practical study, for its object is to facilitate the acquisition of an *Art* supremely useful to its possessor, viz. the *Art* of *Judging soundly* and *Reasoning correctly*. A man's success in life depends upon his ability to form a just estimate of *Evidence* and to conduct rightly the process termed drawing an *Inference*.

Every moment of conscious existence presents opportunities of performing these operations: or rather every moment of conscious existence *necessitates* their performance. We take the *experience* of the *past* as *evidence* from which to infer respecting the *present* and the *future*. We take the *facts* of the present and infer *historically* about the past and *prophetically* about the future. In small matters and in great, all our conduct is moulded by *Evidence* and *Inference*. He who can adequately appreciate the significance of *Evidence* is called *wise;* and he who obstinately misjudges in spite of every indication is called *foolish*.

The prerogative of a conscious being to expect, anticipate, or forestall the order of nature, is necessarily dependent upon the stability of that order. Objects do not exist sporadically, but are found in groups or classes, and events occur in rhythmic series. Hence, our perceptions or experiences of phenomena are not broken or fragmentary, but, one thing is always a *mark*, *sign*, or *token* of another. When we perceive *one* quality of an object, it is often sufficient to convince us of the co-existence or presence of the *others*, so that we are not under the necessity of actually experiencing the *whole*. A child having *once* ascertained that a white powdery substance is connected with an agreeable sweet taste, is under the impression that the *next* white powdery substance presented to it will have the same property. A dog exhibits by a movement of retreat his appreciation of the significance of the uplifted stick. These are *Instinctive Inferences* seeming to spring out of habit or association, and the investigation of their nature and conditions belongs to Psychology.

2. The subject of which Logic treats is *Rational Inference*, or the process of arriving at conclusions on the warrant of given *Premisses*. These Premisses register and embody the knowledge gained by the observation of *facts* by ourselves or others, and are so related that the acceptance of them necessitates the acceptance of the conclusion. The perception of this necessity is the office of the *Faculty of Reason* in all intelligent beings, so that to see the reason of a conclusion is to see its implication in the premisses upon which it is grounded. All the facts of experience are known by intelligent beings in the form of a *proposition*, *statement* or *judgment*. *Objects*

and *events* are the staple of human knowledge; and the constitution of objects and the order of events are the goal of human research. But objects and events before they can become materials for the exercise of the Reasoning Faculty must be *translated* into acts of mind named judgments, which may be expressed in words as statements or propositions. Every addition to our stock of knowledge comes in the form of a judgment. "This flower is fragrant," "This fruit is luscious." Such is the mode in which the mind that knows, reflects the qualities of the object known, separating in thought what is combined in fact, to recombine, as we shall subsequently see, into the general notion of the object.

3. We have said that the evidence embodied in the premisses on which we ground a rational inference, must be matters of fact observed either by *ourselves*, or by *others*. This latter kind of evidence we call *Testimony*, upon the validity of which the soundness of the majority of our conclusions depends. The more educated a man is, the more his mind must be stored with the experience of others in a greater proportion than with his own. Thus it comes that precision of statement is of such paramount importance in the employment of the reasoning faculty. For, not only must the testimony of others be communicated by means of statements, but, we may consider every act of thought to be a statement made to ourselves. Hence, precision of thought and precision of statement should fit like tree and bark, body and garment.

Words are the signs of thoughts as thoughts are the signs of facts. Thought is really the apprehension by ourselves of our own mental processes. Words transfer this apprehension to others. Language is thus the vehicle of thought. This intimate relation between thought and language is signified by the word Logic. The Greek word λόγος means both thought and word, and it has been a much disputed point whether thoughts or words are the legitimate matter of logical enquiry. This question is historically interesting, but, like many of its kind, practically unimportant, for it would be absolutely impossible to consider language and thought as separable factors in the reasoning process.

4. To avoid ambiguity however, as to the view we intend to adopt of the scope and limits of logical science we should define *Logic to be that department of human learning which investigates, discusses, and analyses the nature and mutual relations of Statement, Evidence and Rational Inference.*

5. The following have also been enunciated as more or less comprehensive definitions of the province and function of Logic:

(1) "Logic," says Mr Mill, "is the science of those operations of the understanding which are subservient to the estimation of evidence*."

(2) "Logic," according to Sir William Hamilton, who follows Kant, "is the Science of the Laws of Thought as Thought†." Kant's words are "Eine Wissenschaft von der blossen Form des Denkens überhaupt‡."

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* *System of Logic.* Vol. 1, Int. § 7.

† *Lectures on Logic.* Lect. 1, p. 4.

‡ "Logic is the study of thought pure and simple, or the immaterial types of thought." (Wallace's Hegel, p. 41.)

"The study of truth, or, as it is here explained to mean, consistency, constitutes the proper problem of logic." (*Ibid.* p. 44.)

Thomson and Jevons adopt Sir William Hamilton's point of view as to the province of logical science.

(3) Whately considered Logic to be "the Science, and also the art of Reasoning." "It investigates," says he, "the principles on which argumentation is conducted, and furnishes such rules as may be derived from those principles, for guarding against erroneous deductions*."

6. Each of these *three* definitions presents a single aspect of a subject which properly combines all of them. Hence the supposed distinction between *Formal*, *Conceptual* and *Material Logic*, of which Whately, Hamilton and Mill are held to be the respective expounders. Our view of the legitimate sphere of logical teaching would preclude us from recognizing these distinctions as valid. *The business of Logic* we think *is to examine the processes of acquiring*, *extending* and *communicating knowledge*. The ultra-formal logicians restrict the scope of Logic to the bare consideration of symbolic inference. A mere abstract procedure, demanding at every step a concrete interpretation to give it any significance.

Nature has afforded to man a perfect system of symbols in language. The idea of making an algebra of thought is to assume that the only quality of thought is that of numerical distinctness.

The Conceptualists would make Logic conversant with mere empty thoughts. But it is evident that thoughts would never weave the fabric of knowledge; and it is with the mechanism of the *knowing* and not of the *thinking* process that Logic is concerned. On the other hand Mill's constant repudiation of any mental element in the subject-matter of logical discussion seems inconsistent with his own definition of Logic as a science investigating 'the operations of the understanding,"—these operations are surely mental processes. The matters of fact which he affirms to be the raw material of the reasoning process can only become objects of logical treatment after they have been transformed into mental products. Evidence must be accepted as such by an affirmative act of thought and must be connected into a tissue of proof by comparative acts of thought. We should say then that *symbols*, *thoughts* and *facts* are inseparable elements of the complex organic whole, *Knowledge.* And any logical theory based upon the exclusive consideration of any one of them must be inadequate and unphilosophical. At the risk therefore of appearing to assume an air of gratuitous novelty we have adopted a definition of the purview of logical enquiry which will be found at once *eclectic* and *conciliatory.* With Mill, Bain and Fowler we regard Logic as the *Science* of *Proof*—with Hamilton we admit *proof* to be the comparison and concatenation of ideas, thoughts, notions or concepts, while like Whately, Boole, Jevons, Venn, Keynes and the other formal logicians, we hold the establishment of a universal Form of Inference as a chief aim of Logical doctrine.

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* *Elements of Logic*. Int. p. 1.

7. Starting then from the definition of Logic as the Science of *statement*, *evidence* and *inference* we should in a systematic treatment of the subject consider in the first place the structure and function of Names, and General notions or Concepts, with the rules for their co-ordination and subordination, as signs of generic resemblance and specific difference. Next, we ought to examine the various forms of statement expressed in words as propositions; embodying and registering evidence. Follow-

ing this topic we should come to treat of the procedure of both Immediate and Mediate inference according to the syllogistic method. In the course of discussing this method we should find that *for a syllogism to yield a valid inference there must be at least one universal statement as premiss.* Hence we should be led to the enquiry, How are such universal statements arrived at? Leaving out of consideration certain fundamental axioms whose origin is debatable we must assume that *all objective generalization is a process of Induction.* And hence we should be brought to examine the nature and methods of Induction according to the exhaustive treatment of Mr Mill.

A further topic of Logic which in our opinion demands special and detailed notice is *Error—the disease of intelligence*—its *causes* and *remedies.* And this subject will naturally fall into three subdivisions in conformity with the members of our definition of Logic as Error proceeding from (1) *Inaccurate Statement*, (2) *Illusive Evidence*, (3) *Illegitimate Inference.*

LECTURE II.

NAMES.

8. The recognition of objects by means of their identifying attributes is the primary and fundamental act of knowledge, and the registering and embodying of these identifying attributes in vocal signs or words is the most indispensable requisite of the knowing process. The identifying marks or attributes of an object are a group or cluster of qualities constituting in their relation to him who perceives them what is called a *general notion*, *idea*, *concept*, or *conception* of the object. By virtue of this conception or general notion the same object presents itself as the *same* object to *many* minds, and *many* resembling objects present themselves as similar to the *same* mind. General notions have thus a two-fold generality, as they represent (1) *many* things by a *single* impression, and (2) the *same* thing to *many* minds.

The vocal sign of a cluster of identifying attributes is a name, so that a *general name* records the *common* impression made on a number of individuals by (1) a single object, or (2) a group, or class of resembling objects. This common impression is the aggregate of identifying attributes, and is termed the *connotation* of the name. Thus, the *connotation* of the name horse is the aggregate of identifying attributes constituting the common impression made by a particular kind of animal, while the *denotation* of the name is the whole number of animals possessing these attributes.

The entire utility of a general name depends upon the *community* or *generality* of the mental impression which it represents, for, it is obvious that on this community or generality must depend its efficacy as a means of communication. If the same thing did not produce a certain unity of effect there would be no community of significance. A general name therefore may be considered to be a sign either of (1) a number of resembling things, or (2) of a set of identifying attributes constituting the resemblance of the things, or (3) the *one* impression formed of this set of identifying attributes by each of a number of individuals.

9. Besides general or common names we use proper names to distinguish single objects. They differ from common names by referring to the single object *only*, and not to a set of identifying attributes possessed by many objects. For this reason, a proper name is said to be a *non*-connotative, and can only be made a means of communication by those who are aware of the convention which connects the name with its object—thus, when we speak of a *man*, the object in question is apprehended by every one—but, when we speak of James or John, the objects referred to are not *generally* understood, but *only* by those who have previously been made acquainted with the persons to be designated by those particular names. Many writers think that proper names have a connotation, viz.. the complete set of attributes constituting the indi-

vidual—if so, the connotation of a proper name would be purely arbitrary, artificial and conventional, while that of a general name would be natural and spontaneous. It is probable that a proper name is not a sign of an object but itself forms part of the connotation, as, when a dog is lost part of his set of identifying attributes is evidently his name, as set forth in the advertisement answering to the name of &c. Mr Mill seems to have meant something of this sort when he said proper names were like the private marks of robbers: see Mill's *Logic*, Book I. p. 36.

10. Names are further distinguished as *concrete* and *abstract*. Concrete names are those which may be applied to things as separate individual objects, which are also termed *concrete* objects, as consisting of a concretion, mixture or aggregate of attributes. These attributes although they are found in every possible variety of combination as individual objects are *never* encountered singly or out of connexion with something else. Thus we distinguish *red* in a *red* object, but, we know not of a *red* not inherent in something. Although the abstract *red*, however, has no separate existence, we often require to speak of it as if it had, and in this case we call it an abstract quality or attribute, and affixing a special kind of ending term it red*ness*. Every quality or state although as a matter of fact it can have no existence apart from a thing or object, yet may be separated in thought and distinguished by an abstract name, as *whiteness*, *contentment*.

An abstract name may signify not only a single quality or attribute, but a whole set of attributes making up the entire connotation of the name. Thus, humanity means the whole set of identifying attributes connoted by the general name man.

It will be seen that all connotative names are concrete names, since they stand for *each* of *all* the members of a class, as well as for the set of qualities in which they all resemble one another. Abstract names on the other hand may be said to have no denotation, since they only express *one* quality, or *one* group of qualities. There cannot be more than *one* redness, or *one* humanity, although there are *many* red objects and *many* men. In English the attributive adjective often stands by itself when it signifies a whole class, as *red* means *red* things, *mortal* means *mortal* beings, or a *red* object, or a *mortal* being.

11. There is a kind of name which should be carefully distinguished from general or common names. This is the kind known as *collective names*, which like general names stand for a *group* of objects, but unlike general names cannot be applied to each member of the group, as a jury means a set of men, but is a name which cannot be used to designate any individual juryman taken singly. Collective nouns, however, may also be general names according to the sense in which they are used, thus jury besides meaning a particular set of 12 men may be used to distinguish or comprehend juries of different kinds, as grand jury, special jury, English jury, Scotch jury. In this sense the word jury is like any other connotative name. So library may mean collectively all the books in *one* library or be used of libraries in general, as the British Museum, Bodleian, &c.

12. The property which collective nouns have *not* is that technically called *distribution* i.e. *the capacity of being applied to each* and *every member of a group*. Names

which have this property are called Distributive, so that Collective and Distributive indicate contrasted meanings of names in this respect.

13. Most General Names refer exclusively to the thing they directly indicate, nor do they imply the existence of aught beside. But there are some which derive their distinctive significance from the intimation they convey of the existence of an object, other than that which they immediately designate. Such a word as *father*, for example, in the meaning of which is implicated the notion of the existence of another being called a *child*—or *ruler*, which in like manner requires the fact of the existence of a *subject* to complete its significance. These names are relative terms; they imply the existence of a pair of objects which are said to be correlatives: either member of the couple implicates the notion or possible existence of the other. For, the existence of a subject necessitates that of a ruler, as much as the ruler that of the subject. Every child must have a *father*, as every father, *quâ* father, must have a child. This reciprocal implication of existence between objects is termed *relation*. To the scientific intelligence every object has a relative existence with respect to something else, or, as it is said, nothing exists absolutely or out of relation to anything. But language only records the experience of ordinary modes of apprehension, and therefore only certain very salient instances of mutual dependence, or relativity, call for appropriate vocal signs. Names that do not intimate this dependence are called absolute. Mr Mill says that correlative terms mutually connote each other, so that part of the connotation of teacher, is pupil, and of pupil, teacher. What a relation implies

beyond necessary co-existence is a metaphysical question of some subtlety, but one which Logic need not entertain.

14. There is a special class of relations which language takes cognizance of, and which ought to be noted; this is, the relation of *possession* and *privation*[*]. These are related states, each one implying the notion of the other. All contrasts are of this kind, as *light* and *darkness*, *hot* and *cold*. These names are distinguished as *positive* and *privative*—although it is not always easy to determine which is the positive and which the privative notion implied. In one sense, however, every word intimating the presence of an attribute may have a relation signifying its absence, and language generally supplies negative prefixes or affixes by which the privative notion may be expressed—thus *mortal* and *immortal*, *happy* and *unhappy*, *careful* and *careless*, express this relation. The privative notion can also be conveyed by a periphrasis containing the negative particle, as for "unhappy man" we may say, the man who is *not* happy.

It should be noted that as the negative of the positive notion or term gives us the privative, so the negative of the privative brings us back to the positive, "the man who is not unhappy is happy," i.e. two negatives make an affirmative. It should also be remarked that in consequence of anomalies in the growth of language the negative prefixes *un* and *in* do not always convert a positive into a privative term, thus *in*valuable does not mean value*less*, but an excess of value. Milton writes in his epitaph on Shakespeare,

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[*] According to Hegel many positive and privative conceptions are not antithetical but related as whole and part, e.g. *infinite* and *finite*. The *finite* is only a part of the whole, infinite, and the part implies the whole and the whole the part.

> "the leaves of thy *un*valued book."

This inconsistency of form may arise from the fact that names only register those aspects of things which it is possible for the knowing faculties to apprehend. Thus, for an object to be totally devoid of a quality, and for an object to possess the same quality in such an intense degree as to transcend human ken, would come to the same thing as far as human knowledge is concerned.

15. It is said to be a necessity, or law of thought, that we must think of things as either having, or not having, a given attribute, quality, or determination. A thing must be heavy or *not*-heavy, hot or cold, and the like. But with a notion of a degree or comparison this is not the case, at least it may be contended that a person is not obliged to be either pleased or displeased: he may be indifferent. Two lines may be with respect to each other either *greater*, or *equal*, or *less*.

16. Thomson* distinguishes three kinds of attributes which he calls *contradictory*, *repugnant*, and *compatible*. *Contradictory* are those which we have termed *positive* and *privative*, and which by their very form are necessarily inapplicable to the same object at the same time, because, they would imply opposite determinations, as a thing cannot be *A*, and *not-A*, at the same time. Repugnant attributes are those which experience teaches are incompatible, but whose incompatibility is not evident in the form, as *sweet* and *sour*. Compatible attributes

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* *Laws of Thought*, Part I. § 51, p. 78.

are those which may exist together in the same object at the same time, as *colour* and *weight*.

17. We have now considered the five chief aspects which names present, and under each of which they are divisible into two classes, so that names may be (1) Common or proper, (2) Concrete or abstract, (3) Collective or distributive, (4) Relative or absolute, (5) Positive or privative. All common names are distributive, i.e. can be used to designate a whole class; or, any single member of the class. Common, general, or distributive, therefore equally indicate the two-fold function of those names which Mr Mill calls Connotative.

18. The Connotation and Denotation of general terms which signify their double aspect, as signs of resembling qualities, and signs of groups or classes of objects possessing these qualities, are by some writers termed *intension* and *extension*, respectively. But these terms apply to a general notion, perhaps, rather than to a general name. The intension is the content of the notion, and the extension the range of its applicability, i.e. the number of objects whose appearance corresponds to it. The term *Comprehension* is employed for extension or intension in some manuals.

LECTURE III.

DIVISION AND CLASSIFICATION.

19. LOGIC treats of ***names***, ***notions***, and ***things*** in their mutual relations. We have considered in the preceding Lecture names as the signs of notions and things, we will now examine more closely the logical connexion of notions and things.

General notions, also termed concepts, conceptions, or ideas, are the stored-up results of countless acts of experience, cach act of experience contributing to the perfection of our notion of things, and the systematic correlation of notions constituting the fabric of knowledge. But what are the elements of an act of experience?

First and foremost, experience implies discrimination i.e. the analysis of a vague homogeneous resemblance into its distinct heterogeneous differences or unlike parts, —the perception of difference in the midst of resemblance.

The next important part of the process of experience is the act of Synthesis, or making the distinctions which analysis has revealed the ground of the apprehension of a resemblance, a resemblance made up of marks of difference*. We thus proceed from an unconscious to a conscious resemblance.

20. The operation of perceiving resemblance by means of marks of difference is called *Classification*, and is the stage when Logic begins to take account of the Knowing process. The marks of an object are either its modes of affecting our senses or its modes of affecting other objects. The latter kind is the material of scientific enquiry, the former is the ordinary knowledge of common life. Classification consists of a twofold process, partly positive, and partly negative. For, we apprehend resemblance by the presence of certain marks, while in making a Class of resembling objects we exclude those which have not these marks. In this operation it is evident that the *more* marks we demand as warrant of admission into a class, the *less* will be the number of objects entitled to enter. So that the greater the intension of a Class the less the extension. The process of increasing the extent of a notion by diminishing its intent is termed Abstraction or Generalization; while the converse operation is Specialization or Determination. Thus we specialize Man by increasing the number of his distinctive attributes so that European, Englishman, Londoner, are successively specialized notions of man. But man comprehends many more beings than European, still more than Englishman or Londoner; that is to say, has fewer marks or distinguishing qualities.

21. Classes are actual groups of concrete individuals and are sometimes called logical wholes, while

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* Mansel calls this process "the reunion of attributes previously separated by definition". (*Pro. Log.* p. 209.) Also see Drobisch, §§ 17, 29, 30.

Class-notions or abstract ideas or sets of marks are metaphysical wholes.

Specialization is obviously the dividing or breaking down of a logical whole, but the building up or putting together of a Metaphysical whole. The logical whole or Class man comprises all the inhabitants of this earth, but they are specialized by being divided into European, Asiatic, African, and American, each containing more marks but fewer objects.

22. A Class and its parts obtained by this process of grouping or segregating according to differential marks are termed with respect to one another *Genus* and *Species*—so that European is a species of the genus man, while Englishman is in like manner a species to the genus European. The Genus is termed a *higher* notion than the Species—*wider* would be a more precise appellation, since the less the number of marks in a notion the *broader* the area of objects it embraces.

23. We can ascend to any height of abstraction by divesting Classes of their differential marks and attending *only* to their features of resemblance. Thus we may consider men and other Classes of sentient beings, and find in spite of certain salient differences they all agree in having life, movement, feeling and other attributes or functions. In virtue of this likeness we comprehend them all under a common notion "animal," the extension of which is the sum of the specific Classes.

Similarly we might compare animal with certain other groups of objects which resemble it, in the fact of possessing the capacity of life and growth, but not movement or feeling. Leaving these latter out of account therefore we may again reach a higher or wider Class called "living beings" and so on.

24. Amidst the infinite diversity of objects in the universe the detection of generic resemblance has always been deemed the highest exercise of human sagacity. So also, the discovery of difference latent under superficial resemblance demands an almost equal amount of intellectual acumen. Scientific advance is marked by activity in both directions, and the term invention is equally applicable to either. Evolution regards nature as the manifestation of a myriadfold differentiation of *one* primordial mode of existence, so that knowledge is continually redintegrating that which nature has differentiated. The problem of science is to discover the whole, of which phenomena are the parts.

25. The hierarchical arrangement of notions is what is generally meant by *System*. And the rules of division and definition are designed to facilitate the art of marshalling ideas and the facts they represent in an orderly and methodical manner.

26. Division is the partition of a genus into its constituent species, and the theoretical perfection of the process is ensured by the observance of the following rules:

(1) The constituent species or dividing members must exclude one another.

(2) The constituent species must be equal together to the genus divided.

(3) The division must be made according to one principle or ground.

27. Logical division is useful in economizing memory-power, it also secures coherence of thought and

stimulates suggestion. The rules provided by logicians for the correct performance of the process disclose the elements into which the operation may be analysed. That the dividing members of a Class should be mutually exclusive is of course an obvious requirement, as is also the condition that the *sum* of the species should be equal to the genus. The *third* rule, however, offers the best mental discipline in its application.

28. The ground, or basis, or principle of division* (*fundamentum divisionis*) is some power or quality in the genus capable of manifesting itself in various ways, so that the *diverse* aspects constitute the *specific* difference. Thus, we might classify coins, by taking value as the principle of division, into sovereigns, florins, shillings, sixpences &c., or we might group them according to the date of their issue. In each case the ground or basis is something which must be present in every coin although appearing in different modes in each species. Hence, we cannot agree with Mr Jevons when he states that "in order that a quality or circumstance may be taken as the basis of division, it must be present with some and absent with others" (p. 105, Jevons' *Logic*). In reality the principle must be always present although constantly varied.

29. The process of dividing a Class according to several principles of Division is often equivalent to investigating a subject from different points of view. Thus, in the example just instanced, we regard the coins first from the point of view of the financier, then from the

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* Mr Mansel says, "The principle of division must be given in addition to the concept to be divided." "The specific difference must be added to the given attributes". (*Pro. Log.* p. 207.)

point of view of the antiquary. This procedure necessitates the contemplation of an idea in all its relations and bearings, and in literary composition encourages the lucid and exhaustive treatment of a subject. What is termed a mastery of detail is only the power of exhibiting a question in the greatest possible variety of aspects, each of which may be a dividing principle of a Class. We indeed develope a notion in *two* ways by the process of division, for in seeking for different principles of division we force a problem to disclose many unexpected phases or external relations, while the varieties of species reveal a possible diversity of internal features compatible with the same genus or class. Thus we might regard the question of land-tenure from an economical, moral, social, or political standpoint, and under each of these aspects we might discuss the advantages or disadvantages of any particular system to the individual, the Class, or the Community. So that we should have 12 topics developed for our consideration, each one of which would contribute to the illumination of the whole subject.

30. A *fourth* rule for Division is that a Genus must only be divided into its proximate or next lower species. But, this seems to be necessarily implied in the condition we have already noticed that the principle of division must be part of the intension of the notion divided.

We cannot divide animals into virtuous and vicious because capacity of moral conduct is not part of the intension of the genus animal.

31. These rules are often violated in common usage, —thus a crowd of persons is generally divided into men, women, and children, where sex and age are both simul-

taneously taken as principles of division. This is called cross-division.

32. The ancients had a mode of logical division called *dichotomy** which consisted in dividing the Class into *two* groups, *one* of which *had* and the *other had not* a given *mark*. In this way the division was certain to be exhaustive, the parts mutually exclusive, and the process could be exhibited in pure form. For instance any Class must be divisible into *A*, or not-*A*. We think the method invalid because the negative species does not represent a substantive notion and is therefore devoid of real significance.

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* The well-known tree of Porphyry illustrates a graduated system of division by Dichotomy. Bain, *Inductive Logic*, Appendix K, p. 433; Jevons, Less. xii. p. 104.

LECTURE IV.

DEFINITION AND CATEGORIES.

33. *Definition* is the process of recounting the marks which constitute the notion of a Class. As an exhaustive enumeration of these marks would be tedious and unnecessary it is considered sufficient to state the genus of which the Class is a proximate species, and the differential marks of the species itself. Thus, Man, which is a proximate species of the genus "animal" may be adequately defined as a "rational animal" since, "rationality" is the characteristic distinguishing him from all other kinds of animals.

34. The rules for correct Definition are generally stated as follows:

(1) A definition must recount the essential and only the essential attributes of the thing defined.

(2) The definition must not contain the notion of the thing defined, as this is precisely what we are bound to explain. It is useless to define "life" as "the sum of the vital functions," because "vital" is only the Latinized name of the notion "life." This fault is called *circulus in definiendo*.

(3) A definition must be precisely adequate to the species defined. If it explains a species *below*, it is said

to be too narrow, as when triangle is defined "a rectilinear figure with three equal sides and angles." If it be applicable to the genus *above*, it is too wide, as when we define "words" as "the signs of thought", whereas there are other signs also.

(4) A definition must not be expressed in obscure, figurative or ambiguous language. The object of definition is to proclaim to others, or to realize to ourselves, the marks which entitle the things to be included under a given idea. If, therefore, the expression of these marks is vague it is a sure indication that our conception is confused,—so Hudibras,

> "His notions fitted things so well,
> That which was which, he could not tell."

(5) A definition must not be negative where it can be affirmative. This rule, however, is constantly violated, as in Euclid's definition of a point as "that which has no part and no magnitude." The substantive definition of a point is that which has *position*.

Before noticing further the subject of Definition, we must explain the significance of a set of terms employed technically in Logic and of great historical antiquity, viz. the *Predicables*.

35. The Predicables are the different modes in which a mark, or a set of marks may be attributed to an object, or the different kinds of significance which may attach to a mark, or, a set of marks. Thus the marks composing the notion *man* will constitute a genus if we consider man in respect to the proximate species European, Asiatic &c. or, they will constitute a species if we consider man in reference to a more general form of being called *animal*. Again, when we define man as a "rational animal" the

mark "rational" which distinguishes man from other species of animal, is technically termed the difference. But, besides *genus*, *species*, *difference;* marks, qualities or attributes may have *two* other modes of connexion with the object possessing them, viz. *property* and *accident*. *Property* is the mark of an attribute which flows directly from some defining characteristic of a Class, but is not itself used as *one* of the defining characteristics, thus "moral responsibility" is a necessary consequence of rationality, hence, morality would be a property of man but it is not used as a distinguishing characteristic. A property of a circle is "that a line drawn through the extremity of a radius at right angles touches it," and similarly all the propositions in the IIIrd Book of Euclid are proofs of the existence of certain properties. *Accidents* are marks which are not peculiar to an object, and which may be absent or present without impairing the integrity of the object. Thus a horse may be black, brown, or white, walking, trotting, or galloping.

36. The 5 Predicables then as enunciated by Porphyry are *Genus*, *Species*, *Difference*, *Property*, *Accident*. Aristotle gives 4 Predicables, *Genus*, *Property*, *Definition*, and *Accident*. The *difference*, *mark*, or *marks*, by which the species is distinguished from the rest of its genus, does not occupy a distinct position in Aristotle's list, but, it is said to belong naturally to genus. Definition, indeed, is made up of *genus* + *difference*, therefore Aristotle's enumeration practically comprises the 5 Predicables of Porphyry.

37. The 3 kinds of *predicables* designated respectively *Difference*, *Property*, and *Accident*, evidently denote sets of marks, or part of the intensive character of an

object. On the other hand genus and species when they refer to division have generally an extensive meaning. We think that most of the ancient writers when including them among the list of Predicables employ them also in an intensive signification, conformably to the other 3. This ambiguity in the meaning of the terms genus and species should be particularly noted by the student, as it leads to a further confusion with regard to the nature of the processes known as *Analysis* and *Synthesis*.

38. Analysis simply means the breaking-up of a whole into parts, while Synthesis is exactly the counter-operation of re-constructing a whole out of its parts. But when used of logical procedure the question is, Which is the whole and which are its parts? If we mean by genus and species more or less comprehensive classes, i.e. extensive wholes, then the division of genus into species is a process of Analysis, because the species are parts of the whole genus. But, if we regard genus as an intensive or metaphysical whole, then the same process of Division will be an operation of Synthesis; because, the species has more marks than the genus, which is equivalent to saying that the genus is part of the species. Sir W. Hamilton was the first to notice the inextricable confusion imported into Philosophy by the loose application of these terms Synthesis and Analysis*. Analytical Reasoning and Synthetical Reasoning, Analytical Propositions and Synthetical Propositions are spoken of as counter to

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* A recent writer remarks, "All analysis presupposes a corresponding synthesis". (M. Martin, *Mind*, XXX.) Kant constantly uses the terms Analytic and Synthetic Unity, and we are inclined to think much of the discordance of his commentators arises from a failure to appreciate the cause of confusion.

each other. Whereas, as we shall presently see, all reasoning and all predication is both Synthetical and Analytic, according as we consider the notions employed to be intensive, or extensive wholes. Sir W. Hamilton also drew attention to the relation subsisting in all notions between these two aspects, viz.: that, as the intension increases the extension diminishes and *vice versâ*. A horse has more intension, but less extension than an animal.

39. The object of Logical definition is to secure agreement in discourse as to the exact Classes of things which our names signify—these classes being real, or imaginary. Such a process is rendered indispensable partly by the shifting meaning of words, and partly by the symbolic character of general notions.

Philologists are not in agreement as to the exact degree of arbitrariness attaching to names. The historical growth of language is a natural phenomenon, not the result of human enactment. Its progress is therefore by insensible gradations, the change in the significance of words is due principally to the continuous modification undergone by the notions they embody. From age to age the thoughts of men are widened, and every stage of knowledge compels a recasting of ideas which have become obsolete. Locke notices the extraordinary vagueness of ideas which are nevertheless employed without misgiving. He relates how, in the company of a number of men of science, the question was being discussed, whether the nerves could conduct fluids. After a time it occurred to somebody to ask, what was to be understood by the term *fluid?* when it was discovered no one present had a precise notion as to the thing intended.

40. The explication of ideas is *scientific definition*, as distinguished from the mere unfolding of the meaning of names which is *logical definition*. In the 1st Book of Plato's Republic we have an example of an attempt to define the notion of Justice by a process of elimination. Various kinds of acts are adduced as just which are successively rejected because they do not satisfy the idea of Justice as conceived in the minds of Socrates and his interlocutors. This method was based upon the assumption that where there is a notion common to many intelligences, there must be some reality corresponding in actual existence, an assumption which afterwards appeared in the doctrine of Realism so prominent in the Scholastic philosophy and so potent in obstructing the advance of genuine knowledge. Although this doctrine in its cruder forms of archetypes and essences is extinct, it still survives so persistently that its influence seems ineradicable. Mr Spencer's criterion of truth for instance that—"that which cannot but be conceived, must be true". The idea of evolution as the true process of change in nature, is, but a notion projected into fact and mistaken for an idea born of fact.

41. The famous Categories of Aristotle are an attempted enumeration of the various kinds of defining marks which determine the nature of a phenomenon, and the apprehension of which constitutes our knowledge of it. If we hear of an occurrence we instinctively enquire, *Where* did the event happen? *When* did the event happen? &c. Or, if we perceive an object our recognition or *non*-recognition of the same depends upon our ability to answer certain questions respecting it, as, *What* are its component elements or essences? *What* are its

sensible qualities? &c. Aristotle's table comprises the replies to *ten* such questions, viz.

Οὐσία.	Substantia.	Substance.
Ποσόν.	Quantitas.	Quantity.
Ποιόν.	Qualitas.	Quality.
Πρός τι.	Relatio.	Relation.
Ποιεῖν.	Actio.	Action. Function.
Πάσχειν.	Passio.	Capacity. Passion.
Ποῦ.	Ubi.	Where. Position in *Space.*
Πότε.	Quando.	When. Position in *Time.*
Κεῖσθαι.	Situs.	Locality.
Ἔχειν.	Habitus.	Sphere.

Mill dismisses this list with a somewhat cavalier criticism, "The imperfections (he says) of this classification are too obvious to require, and its merits are not sufficient to reward, a minute examination." "It is a mere catalogue of the distinctions rudely marked out by the language of familiar life*." In our opinion Mr Mill has mistaken the nature and design of these Categories which he considers "an enumeration of Existences," whereas, we hold that they refer not to the Extension, but to the Intension of Class notions. They are, in short, not an enumeration of existences at all, but an enumeration of the necessary modes of all phenomenal existence. Kant the great German philosopher of the last century adopted the term Category and employed it in this latter sense. On a classification of these Categories he based his theory of knowledge; his standpoint was so far different, however, from that of Aristotle, that with him the Categories were intended to exhibit the *necessary modes* of *experience*, not as with Aristotle the *necessary modes* of *Existence*.

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* Mill's *Logic*, Vol. I. p. 50.

Kant's Categories are four—*Quantity*, *Quality*, *Relation*, *Modality*. As they are necessary modes of Experience they may be looked upon, either as the ultimate, distinctive forms of every act of experience *present*, *past* and *future*, or as the necessary conditions to which things must conform, in order to be capable of becoming objects of experience. Kant's Categories have therefore a double import and a double function, they determine the possible kinds of experience as a subjective operation, and they determine the possible kinds of things experienced as objective facts. In this latter sense they would approach more nearly to the "Categories" of Mr Mill which are designed to be an exhaustive division of all matters of fact capable of being named, distinguished and thought about. Mr Mill divides knowable things into three Classes (1) Feelings, (2) Substances, (3) Attributes.

LECTURE V.

PROPOSITIONS OR STATEMENTS.

42. A *Proposition* or *Statement* is the *vocal* or *verbal* expression of a *mental* impression. This mental impression is termed a *Judgment*. A Judgment is an act of thought by which the phenomena of nature are transmuted into human experience or knowledge. A Proposition or Statement therefore is directly the means by which the operations of *one* mind are made known to another:—and indirectly the means by which the facts and operations of objective nature are realized and registered by *universal* consciousness. Dr Thomson, in conformity with the Kantian doctrine, says "an act of Judgment is an attempt to reduce to unity two cognitions. When one decides that 'Socrates is wise' it is that hereafter one may, by combining the two notions think of 'the wise Socrates'." (*Laws of Thought*, § 67, Part II.) So Mr Wallace writes "Every proposition is synthetical, it unites or identifies what is supposed to be implicitly different." (Hegel's *Logic.*)

43. The purely logical view of a proposition is to consider it as the mere form of affirmation and denial without reference to what it is that is affirmed or denied.

Aristotle, the first expounder of logical doctrine, defines a proposition (πρότασις) to be "A sentence which affirms or denies something of something else." (*Pr. Anal.*) A Proposition has been variously held by different writers to express a relation of *ideas*, a relation of *things*, or a relation of *words*. We shall adopt the view of Mill and consider propositions as,—the *verbal vehicles of evidence, furnished by the senses, of the objects* and *processes of nature.*

44. A Proposition is analysed into three parts, viz. *Subject*, *Predicate*, and *Copula*. In the statement, "Every circle is round", *circle* is called the subject, *round* the predicate, and *is* the copula. For a statement to become susceptible of logical treatment it must always be thrown into this form and no other, whatever may be the idiom of the language in which the assertion is made. In English, and most other languages, the predicate is generally fused with the copula in a verb, but for logical purposes the copula and predicate must be disengaged. Thus the assertion "Cats eat mice" must be expressed in the form "Cats are eaters of mice." Logical sentences in short must only contain nouns and adjectives, or phrases equivalent to nouns and adjectives. In the assertion "No slave respects himself" we might write for slave "one who is not master of himself", when the assertion would stand in complete logical form "No one who is not master of himself is a respecter of himself." The verb in speech is only a condensed form of predication.

45. The subject and predicate of a proposition are designated *Terms*. These Terms may be joined in the relation either of affirmation or denial. This distinction constitutes what is called the quality of a proposition. The quality of a proposition therefore is the distinction

expressed in the affirmative or negative form by which the subject and predicate are stated to be or not to be connected.

The negative particle *not* in a negative proposition is to be understood as part of the copula, but in universal negatives the negation is generally expressed in the subject, to avoid an ambiguity which would otherwise arise. For instance, "*All* students are *not* industrious." If we wish to express a universal negative in this proposition, i.e. to exclude "all students" from the class "industrious," we must state it in the form "*No* student is industrious," otherwise the statement "*all* students are *not* industrious" might be taken to mean merely "*some* students are *not* industrious." The learner will do well, however, to remember that the negative particle in the subject properly belongs to the copula.

46. It should be particularly noticed that *the quality of a proposition as far as the form is concerned may always be changed without affecting the content, matter or meaning*, so that a negative proposition may become an affirmative and an affirmative a negative. This change may be made by detaching the negative particle from the copula and attaching it to the predicate, or employing instead of the predicate its corresponding privative term—thus "*No* vicious man is *happy* = *all* the vicious *are-not happy* = *all* the vicious *are not-happy* = *all* the vicious *are unhappy*." Here the first two forms are negative and the other two affirmative, but the meaning is equivalent in each case.

47. The subject and predicate of a proposition may be names signifying either an entire class or part of a class, or as it is usually expressed, the terms of a proposition may be either *distributed* or *undistributed*. If the entire class is

meant or the term is to be distributed the pronoun *all* which stands for *each* and *every* is used, as "*All* quadrupeds are vertebrate." If only a portion of the class is spoken of or the term is to be undistributed the pronoun *some* is employed, as "*Some* quadrupeds are predacious." When a proposition has the subject *distributed* it is said to be universal, when *undistributed* particular. This distinction is termed the quantity of a proposition.

48. There is a third form of statement called a singular proposition when the subject is neither the whole nor the part of a class, but only a single object, as "This book is interesting," "Bayswater is a suburb of London." Most writers, however, include this kind of judgment under *Universals*, because like them the predicate is affirmed or denied of the whole of the subject, although this whole is comprised in one object.

49. The different kinds of propositions are generally distinguished by the vowels *A*, *E*, *I*, *O*, &c. The learner will find it advantageous to commit to memory the following table:

		Quant.	Qual.
A.	All cowards are selfish.	Univ.	Affirm.
E.	No pleasure is lasting.	Univ.	Neg.
I.	Some movements are involuntary.	Part.	Affirm.
O.	Some men are not humorous.	Part.	Neg.

These statements or enunciations are termed categorical propositions as distinguished from hypothetical and disjunctive propositions, the nature of which we shall presently describe. The character of a categorical proposition is, that it lays down or posits something directly, absolutely or unconditionally.

50. When we affirm as in *A* "*all cowards are selfish,*"

we may read the subject and predicate either in intension or extension—that is to say, we may either consider "*cowards*," "*selfish*" to stand for classes of beings or for the groups or aggregates of marks which make up the notion of *coward* or *selfish*. In short, they may mean either aggregates of beings or aggregates of marks. If they represent aggregates of beings, then what is asserted in the proposition is, that the class of persons called "*cowards*" is comprised in the class of persons called "*selfish*"—or, in other words, the subject is contained in the predicate. On the other hand if "*coward*" and "*selfish*" stand for aggregates of marks, then we are to understand that what is asserted is, that among the aggregate of marks constituting the notion "*coward*," there will be found the marks which constitute the notion "*selfish*," which is equivalent to saying that the predicate is included in the subject. It will be observed, that, as far as the practical significance of a proposition is concerned, both interpretations amount to the same thing, for, to affirm that cowards possess the quality or attribute of selfishness is precisely the same as to affirm that they are included under the class of selfish beings. The common language of logical treatises seems, however, to incline to the interpretation of a proposition as an inclusion of the subject in the predicate.

51. By this view, a difficulty is introduced respecting the natural quantity of the predicate, for it will be noticed that no sign is attached to the predicate from which we may understand whether *all* or *some* of the class is to be understood. In the common manuals of Logic it is generally laid down that the predicate must be held to be undistributed in affirmative propositions and dis-

tributed in negative, so that the proposition "*All cowards are selfish*" is tantamount to "*All cowards are some selfish beings.*" In negative statements, however, since the subject is excluded from the predicate, we are to consider that it is excluded from the whole of the predicate, or in other words the predicate is distributed. In ordinary Logic then the assumption is, that in affirmative propositions the predicate is undistributed, in negative propositions the predicate is distributed. Most of the rules for correct reasoning are founded upon this supposition and the student had better consider it the orthodox doctrine. Hobbes rejected the mutual implication of subject and predicate in a proposition and sought to reduce their relation to one of equality. This idea has been revived by Boole, Jevons and other writers of the present century, by whom Logic has been reduced to a science of formal computation. The proposition with them is an equation or identity*.

52. Sir W. Hamilton will not allow any valid theory of predication which does not admit a quantity to the predicate. Such a quantification is *implicit in thought* he maintains, and whatever is implicit in thought should be made explicit in words.

Dr Thomson adopts Sir W. Hamilton's doctrine so far as to include *two* other forms of judgment in addition to the *four* above enumerated, viz. *U*, "*all A is all B*," and *Y*, "*some A is all B*." These are certainly useful forms of expression. The kind of statement known as *definition* is really a proposition of the form *U*. "Man is a rational animal" means "*All* men are *all* rational animals," since there are "*no* rational animals who are not men."

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* See Mill's *Logic*, Book I. ch. v.

Again, according to the idiom of the English language many statements are cast in the form of the *Y* proposition, viz. sentences beginning with *none but* and *only*. "None but the virtuous are happy" means "Some virtuous are all the happy." In ordinary Logic these are transposed into "All the happy are virtuous," which is an equivalent statement in the form of an *A* proposition.

53. The inconsistency of logical writers in expounding a satisfactory theory of predication arises from a failure to apprehend the real nature and function of Judgment. What is it that a proposition is used to express?

Mr Mill writes "that in all propositions of which the predicate is a concrete name, what is really predicated is one of five things, Existence, Co-existence, Causation, Sequence, or Resemblance." In truth, however, a proposition states as many modes of existence as there are verbs in a language, or, if we wish to generalize the contents of a natural statement, we should say—that, what a human being wishes to express is, either the occurrence of an event, or the ascription of some property, attribute, or quality to an object. Scientific predication has more often in view the classification of objects for the purpose of abbreviating the processes of research.

54. Kant attempted to institute a distinction between what he termed Analytic and Synthetic judgments, corresponding to the ancient difference made by the schoolmen between Verbal and Real Propositions. In an analytical statement the predicate is an integral part

of the subject, and the act of thought expressed by the proposition is the analytical separation of the predicate from the subject, of the intension of which it was known to be a constituent part. Thus, when we say, that "body is extended" we merely assert that the quality extension is attached to body—from which we already knew it was inseparable—so that the statement is devoid of real information. On the other hand, synthetic propositions convey the intimation that a certain predicate is united with a certain subject, although not forming part of its natural connotation. "All bodies are heavy" is a synthetic proposition, because weight does not form a necessary element of our conception of body and its inclusion in the subject is just what the proposition affirms.

55. I do not think that this distinction is valid, because it depends entirely on the state of our knowledge whether any property, attribute, or quality is or is not an essential constituent of our notion of the subject, so that a synthetic proposition of one age might be analytic in the next. It is, however, certain that the judging act may both separate and combine: *All primary acts of sensible experience are analytical judgments.* When we first distinctly realize that "snow is cold" we separate or analyse in thought what is inseparable in fact, but subsequently we combine the attribute of coldness with other qualities to make up our notion of snow. Conception is combination or synthesis. Perception is separation or analysis; but both are acts of judgment.

56. On these contrasting functions of the judging faculty we might base a useful division of propositions into *subjective* and *objective statements.* Subjective pro-

positions or statements would be the expression of analytic perceptions, or intuitive acts of mind, while objective propositions would be the enunciation of synthetic conceptive operations of the understanding. All assertions of past or present personal experience would be subjective or analytical. All general declarations respecting the constant conjunction of phenomena as experienced by *every one at all times* may be classed as Synthetic or Objective propositions—"This snow is cold," or "This fire is hot," would be the intimation of a process of analysis made by the senses and recording simply our own personal experience. But the affirmation that "All fire is hot," "All snow is cold," would proclaim *not a subjective personal past experience but a universal impersonal objective expectation in the future.* All inductive generalizations stating the coherence of physical phenomena are synthetic and objective propositions. It is perhaps these which Kant seems to have in view in emphasizing the distinction between analytic and synthetic judgments.

LECTURE VI.

HYPOTHETICAL AND DISJUNCTIVE PROPOSITIONS AND THE LAWS OF THOUGHT.

57. A Categorical Proposition is as we have seen one in which an affirmative or negative statement is enunciated or laid down absolutely and unconditionally without reference to the acceptance or rejection of any other statement or declaration. There is, however, a very important class of propositions called Hypothetical in which the connected members are not simply a subject and predicate as in Categorical Propositions, but are a pair of statements connected or joined by the copula *if* in a relation of dependence on each other. In Categorical Propositions, therefore, the relation of subject and predicate is one of inherence or co-existence, while in Hypotheticals the relation is one of definite dependence or conditionality. A categorical judgment states simply that A is B, but in a hypothetical it is asserted that if A is B, C is D. Hence in a hypothetical statement there is always an idea of contingency if we are referring to existence, and if we are referring to mere assertion or denial the admission or rejection of some previous statement is always involved.

58. *Hypothetical propositions are the form of state-*

ment by which the causal relation between things and events is directly expressed in words, i.e. when we say "If the moon is full, the tides will be high," we mean to express the causal connexion between the moon and the tides. The same form is also employed for the direct expression of the connexion between the sign and the thing signified; thus, when we say "If the barometer is high, the weather will be fine," we mean the height of the barometer is a symptom connected with certain atmospheric conditions favourable to fair weather. These relations are among the most important in experience and the form of their verbal exponents should be, therefore, carefully noted.

59. The conditional statement or assertion is called the Antecedent, and the dependent assertion is the Consequent. Both Antecedent and Consequent are distinct categorical statements in themselves. The significance of these in a hypothetical judgment is derived not from their separate validity but from their declared dependence. The contradiction of hypotheticals, therefore, consists in severing the dependent relation of antecedent and consequent, not in impugning the antecedent or consequent itself. This relation may be severed at once by an appeal to facts, as if we should shew that on a given occasion, the moon being full, the tide was not high. An exhaustive discussion, however, of the process of cognition through the law of causation must be reserved for a later chapter.

60. Another form of statement much employed is the Disjunctive or Alternative Proposition. This kind of proposition states that a given subject may be connected with one or other of two or more predicates with-

out specifying which. Such a judgment is of the form, *A* is either *B*, or *C*, or *D*. The exact interpretation of such a proposition will depend upon the import we attach to the corresponding categorical. We can say that the genus *A* may be divided into the species *B*, or *C*, e.g. "animals are either bipeds or quadrupeds." Or, we may say "man is either mortal or immortal," meaning that he must belong either to one or other of these classes. To have a quality and to belong to the class possessing such a quality is the same thing.

61. Both Hypothetical and Disjunctive Propositions may be reduced into the form of categorical statements. Thus the proposition "If *A* is *B*, *C* is *D*," may be equivalently expressed in the form, "the case of *A* being *B*, is a case of *C* being *D*." *A* is either *B*, or *C*, may be also expressed by the statement "the case of *A* being *B*, is a case of *A* not being *C*"—there being always an implication in disjunctive propositions, that the alternative predicates are mutually exclusive. On the other hand it would be equally easy to embody a categorical statement in a hypothetical proposition. Thus, the assertion that "*A* is *B*" would be adequately expressed by the hypothetical judgment "if *A* is, *B* is." But there is no advantage gained by such artificial conversion of form. It is evident that different forms of statement are best adapted to the expression of different relations between matters of fact. Categorical Propositions state the relation of co-existence between things and attributes. Hypotheticals by their form predicate the relation of sequence and dependence, while disjunctions are fitted to express the relation of discrimination or mutual exclusion and contrast.

62. Another quality of judgment considered by logicians is that termed Modality; by Modality is meant the implication in a statement of certain degrees of actuality. These are three, viz. *Possibility*, *Contingency*, and *Necessity*. Under the *first* a statement *may* or *may not be true*, for as long as it is possible its truth or falsehood may be capable of demonstration. If a statement is contingent, its truth or falsehood is definitely conditioned by some known circumstance. If a proposition is necessary its truth is unconditional.

According to what was said in the preceding lecture, it is plain that all analytical propositions are *necessary*, while synthetic propositions may be *possible* or *contingent*. All statements concerning past events contain an element of necessity, inasmuch as that which has occurred is irreversible. So, all statements respecting the future imply a degree of contingency, at least, unless we are prepared to adopt the ontological theory of evolution, which would make the past and future equally necessary.

The formalist and conceptualist logicians do not accept modality as a part of logical doctrine. The formal logician is only concerned with the relations of symbols with which of course possibility of existence has no place. Formal logic is the logic of consistency and implication, not of facts but of symbols.

Again, the conceptualists regard logic as only employed on a relation between notions or concepts. But here, unless we import some knowledge of the matter, we should not be able to assert any congruity or incongruity in mere ideas considered as such. However, conceptualist logicians are seldom content to remain within the limits of the science as restricted by themselves. The void notions somehow always acquire definite connotation which often includes possibility, contingency and necessity. But the conceptualist would maintain that these degrees of actuality were consequent upon the *laws of thought.* As this phrase *laws of thought* is a very common occurrence in logical doctrine we will here consider its meaning*.

63. A law, in the common acceptation of the word, is a uniform mode of behaviour prescribed by one who has the power to enforce it. But the word law has been appropriated by every science and has lost most of its original meaning in the process of transplanting, until in scientific usage the only trace it retains of its original signification is the import it conveys of a *uniform* mode

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* Thomson says, "the degree of certainty with which a judgment is made and maintained is called its modality, as being the *mode*, or measure, in which we hold it to be true. We affirm with very different degrees of assurance the two judgments, that 'an equilateral triangle is equiangular,' and that 'Zeno of Elea was the inventor of dialectic,' since we can prove the former to demonstration, whilst doubts may be entertained as to the evidence on which the latter rests." (Thomson, *Laws of Thought*, par. 67, p. 130.) It would seem from this view of modality, propounded by one of the conceptualist school of logicians, that they regard it as a purely subjective characteristic of a statement, not importing any objective distinction whatever. Notwithstanding this Thomson considers modality as only having a place in *applied* Logic, on the ground (as he says) that the modality of a judgment is not part of itself and does not belong to the copula. Doubtless the degree or mode of certainty must be either a *subjective* or *objective* quality of affirmation. Thomson from the above definition evidently regards it as subjective, but singularly enough banishes it from the consideration of Formal Logic, because it is objective. The doctrine of modality, however, is closely connected with and dependent on the so-called laws of thought.

of procedure. Any *uniform* mode of *operation or course of procedure is now called a law. A law of thought* is a uniform mode of thinking, supposing that all thinking beings think in the same way at all times. But besides the element of uniformity, this term law is generally intended to imply a certain degree of necessity, a survival probably of its original meaning—not only *do* men think in a certain manner, but they *must* think in conformity with this rule.

64. The only universal relation disclosed by every act of thought or comparison between two mental presentations is their resemblance or difference, and this relation is expressed by the two propositions *A* is *A*, or *A* is not *B*. Or, we are compelled to admit that *A* is *A*, and that *A* is not *B*, supposing *A* and *B* to represent distinct mental states. Most works on Logic enunciate three laws of thought, some four, viz. (1) The law of Identity, *A* is *A*. (2) The law of Contradiction, *A* cannot both be *B* and not *B*. (3) The law of Excluded Middle, *A* must either be *B* or not *B*. (4) The law of Sufficient Reason, by which everything that is thought or happens must have a ground or cause or determining agency. All these laws are supposed to command assent by their native necessary indefeasible cogency, and are therefore fit to be the foundations of all reasoning.

65. We prefer the "laws of thought" in the form in which they have been stated by Locke—as the limitation of human knowledge, viz. the perception of the agreement or disagreement of our ideas—*A is A*, or *A is not B*. The perception of agreement and difference is the form of all comparison in all minds and may therefore be justly termed the formal law of thought—and

the propositions embodying this law are modally necessary, i.e. compel acceptance by their very statement. Beyond this the so-called Laws of Thought are mere empty forms and dependent for their whole significance upon the matter they contain. Nay, their very existence is involved in their *content*, for to think at all, we must think of something—to compare at all we must have objects of comparison. Thought is a function whose essence is activity, whose product is the apprehension of a relation between two actual terms. A law of thought might thus be defined to be *that universal* and *necessary relation of mental states which is disclosed in every act of thinking*, viz. the relation of resemblance or difference, or, as Locke terms it, of congruity or incongruity.

LECTURE VII.

THE CATEGORICAL SYLLOGISM.

66. A Syllogism is a set of three propositions, enunciations or statements: two of these are termed the premisses, the third the conclusion; and they are so connected that if the two premisses be *known*, *granted*, or *believed* the conclusion must likewise be accepted. The process which the syllogism exhibits is called proof or argument; and it is the verbal exponent of the mental operation termed reasoning or deduction. The act of perceiving the implication of the conclusion in the premisses is called Inference. This term is sometimes applied to the conclusion itself. The premisses are also spoken of as reasons, principles or assumptions. There are three ways in which the syllogistic process may be presented, the Categorical Syllogism, the Conditional Syllogism, and the Disjunctive Syllogism.

67. The method of implication which the Categorical Syllogism employs, is that of Inclusion. We wish to show that a certain subject is included in a certain predicate, but we are unable to perceive this implication immediately: we therefore take what is called a Middle Term, in which we know, or admit, the subject is con-

tained, and which Middle Term itself we also know is part of the predicate. Now that which is involved in a part must be involved in the whole to which that part belongs: therefore the subject being involved in the part of which the predicate is the whole, must necessarily be involved in the predicate itself. Thus suppose we wanted to prove that "the industrious are happy" we might not be able to show this directly, but it might be admitted that "the industrious enjoy the best health", and that "those who enjoy good health are usually happy". Hence we should be constrained to grant from the premisses accepted, or reasons assigned, that "the industrious are happy". Here the Middle Term expresses the class of persons enjoying "good health;"—the Subject, the class of "industrious" persons;—and the Predicate, the class of those who are "happy." The syllogism proves that the class of "industrious" persons is included in the class of the "happy", because the "industrious" are included in the class of the "healthy", and the "healthy" again are included in the class of the "happy". All this is briefly expressed in common discourse when we say that "the industrious are happy because they are healthy," or "the industrious are healthy; therefore they are happy."

68. Again, we may on the same principle demonstrate that a certain subject is disconnected with, or excluded from, a given predicate, for if it be allowed that the class represented by the subject is contained in a class represented by a middle term, and that this middle term is *excluded* from the class represented by the predicate, then it is evident that the subject does not form part of the class represented by the predicate. Thus supposing we

wanted to convince any one that "flatterers are not true friends", we might have it granted that "flatterers are insincere", and that "insincere persons are not true friends". Hence the conclusion that "flatterers are not true friends" must be allowed. The syllogism is thus the form of inferring either an affirmative or a negative proposition.

69. The following are the rules which must be observed in the construction of the Categorical Syllogism:

1st. *Every Syllogism has three, and only three terms;* viz. the middle term and the two terms (or *extremes*, as they are commonly called) of the Conclusion. Of these, the subject of the Conclusion is called the *minor-term;* its *predicate* the *major-term;* and the *middle-term* is that with which each of them is separately connected, in order that the connection of the other two may be established.

2d. *Every Syllogism has three, and only three propositions;* viz. the *major-premiss*, in which the middle-term is connected with the major-term or predicate of the Conclusion. The *minor-premiss*, in which the minor-term or subject of the conclusion is connected with the middle-term; and the *Conclusion*, in which the Minor-term is connected with the Major.

3d. *The middle-term must not be ambiguous in meaning*, i.e. it must have the same *denotation* and *connotation* in both premisses.

4th. *No term must be distributed in the conclusion which was not distributed in one of the premisses.*

5th. *From two negative premisses nothing can be inferred.* For the subject and predicate of the conclusion could not be shown to be connected or related by means of a middle term, which had no connection or relation with either of them.

6th. *If one of the premisses is negative, the conclusion must be negative;* for in that premiss the middle term is pronounced to be disconnected with one of the Extremes, and in the other premiss (which of course is affirmative by the preceding rule) to be connected with the other extreme; therefore the Extremes are disconnected with each other, or the Conclusion is negative. And conversely, to prove a negative Conclusion it is manifest that one of the premisses must be negative.

7th. *The middle-term must be distributed or used to designate a whole class in one or other of the premisses.* Unless this condition be complied with, the middle-term would not avail to prove the connection or disconnection of subject and predicate in the conclusion.

70. From these seven rules two important corollaries flow, viz.,

1. *From two particular premisses no conclusion follows.*

2. *If one of the premisses be particular the conclusion is particular.*

The first of these corollaries is involved in Rules 4 and 7. The second in Rule 4. They may be thus explained*. If each premiss were *I*, there would be no distribution of any term at all, so rule 7 would be violated. And if the premisses were *I* and *O*, there would be but one term, the predicate of *O*, distributed. And supposing that one to be the Middle Term, then the Conclusion being of course negative by Rule 6, would have its predicate the Major Term distributed, which was undistributed in the premiss. Hence rule 4 would be broken. The reason of the second corollary is obvious, from similar considerations.

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* Whately's *Elements of Logic*, p. 56, § 2.

71. The following Table shows the different ways in which the subject and predicate of a conclusion may be connected or disconnected through a middle term in the premisses of a Categorical Syllogism. Let *S* represent the Subject, *P* the Predicate, *M* the Middle Term; then

FIG. 1.

BARBARA *.

A. All *M* is *P*,
A. All *S* is *M*,
A. ∴ All *S* is *P*.

CELARENT.

E. No *M* is *P*,
A. All *S* is *M*,
E. No *S* is *P*.

DARII.

A. All *M* is *P*,
I. Some *S* is *M*,
I. ∴ Some *S* is *P*.

FERIO.

E. No *M* is *P*,
I. Some *S* is *M*,
O. ∴ Some *S* is not *P*.

FIG. 2.

CESARE.

E. No *P* is *M*,
A. All *S* is *M*,
E. ∴ No *S* is *P*.

CAMESTRES.

A. All *P* is *M*,
E. No *S* is *M*,
E. No *S* is *P*.

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* Fig. I. Barbara, Celarent, Darii, Ferioque *prioris*.
„ II. Cesare, Camestres, Festino, Baroko, *secundae*.
„ III. *Tertia*, Darapti, Disamis, Datisi, Felapton,
Bokardo, Ferison, habet.

These mnemonics first appeared in the *Summulae Logicales* of Petrus Hispanus, afterwards Pope John XXI. (about 1270). They were designed amongst other purposes to aid the logician in remembering the valid moods of each figure. For full explanation of their significance see Whately, pp. 57 to 64.

FESTINO.

E. No *P* is *M*,
I. Some *S* is *M*,
O. Some *S* is not *P*.

BAROKO.

A. All *P* is *M*,
O. Some *S* is ∧ *M*, ∧ not
O. Some *S* is not *P*.

FIG. 3.

DARAPTI.

A. All *M* is *P*,
A. All *M* is *S*,
I. Some *S* is *P*.

DISAMIS.

I. Some *M* is *P*,
A. All *M* is *S*,
I. Some *S* is *P*.

DATISI.

A. All *M* is *P*,
I. Some *M* is *S*,
I. Some *S* is *P*.

FELAPTON.

E. No *M* is *P*,
A. All *M* is *S*,
O. Some *S* is not *P*.

BOKARDO.

O. Some *M* is not *P*,
A. All *M* is *S*,
O. Some *S* is not *P*.

FERISON.

E. No *M* is *P*,
I. Some *M* is *S*,
O. Some *S* is not *P*.

72. It will be seen by the preceding scheme that each of the syllogisms in Figure I. has the Middle Term for a subject in the major premiss, and for a predicate in the minor. In Figure II. the Middle Term is the predicate in both premisses. In Figure III. the Middle Term is a subject in both premisses. Each sequence of three propositions which make up the syllogism is called a *mood*, so that there are four distinct moods in Figure I., four in Figure II., and six in Figure III. There are really sixty-four possible varieties in the sequence of three propositions constituting a possible syllogism. But

the student will perceive that all other combinations besides those given fail to comply with the rules previously stated for the construction of a valid syllogism. Or, it would be found that the connection or disconnection of the subject and predicate in the conclusion had not really been exhibited by means of the Middle Term. Some logicians include a fourth figure in the scheme of valid syllogisms, in which the Middle Term is predicate to the major premiss and subject to the minor. *P* is *M*, *M* is *S*, therefore *S* is *P*. This form is however very clumsy and unnatural, being only a distortion of the first figure. It will be observed that the syllogisms set forth above only comprise various combinations of the four propositions *A*, *E*, *I*, *O*, recognized by the older logicians. If, however, we take into consideration the propositions *U* and *Y*, added by Sir Wm. Hamilton and Dr Thomson, we shall find that there are many new forms of syllogism which can be constructed so as to show the connection or disconnection of a given subject or predicate by means of a Middle Term. The learner will find it a good exercise to set forth for himself the additional syllogisms in each figure arising from the admission of the *U* and *Y* forms of propositions.

73. It will be also noticed in the foregoing list of syllogisms, that the Conclusion in Figure I. may be a proposition of any of the four forms *A*, *E*, *I*, *O;* that in Figure II. the Conclusion must be negative, i.e. of the forms *E*, or *O;* that in Figure III. the Conclusion must be particular, i.e. of the forms *I*, or *O*. Hence the first figure is the only one adapted to exhibit every kind of argument or proof. But by a process called Reduction,

each syllogism in the second and third figures may be turned into an equivalent syllogism in the first figure*. It may be remarked also that Moods which are valid in one figure need not necessarily be so in the others. For example, *A A A*, Figure I. would not yield any proof in Figures II. or III. as such a sequence in these figures would break one or other of the rules of valid syllogism.

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* For a description of this process, termed Ostensive Reduction, see Whately's *Elements of Logic*, p. 61.

LECTURE VIII.

HYPOTHETICAL SYLLOGISMS, ETC.

74. We have hitherto examined the structure of the Categorical Syllogism consisting of three Categorical Propositions, of which one, the Conclusion, is an assertion warranted by its implication in two other assertions called premisses. In such a process of reasoning the implication is one of whole and part. There is, however, another and distinct mode of inference founded upon the implication of Causal Dependence in the premisses, and which is very important because it is the rational expression of inference from evidence grounded on the observed conjunction of phenomena or events. This is called the Conditional Syllogism, a description of which we take from Whately's *Elements of Logic* (p. 68). The meaning of a Conditional Proposition is, that if the Antecedent is granted, the Consequent is granted. Hence if we admit the proposition, if A is B, C is D, and also grant that A is B, then we are constrained to allow that C is D. "If a man has a fever he is not fit to travel;" "he has a fever; therefore he is not fit to travel." This is termed a *constructive* Conditional Syllogism, where the Antecedent being granted the Consequent must also be allowed. Again, if the Consequent be not allowed

the Antecedent cannot be admitted. If you refuse to admit *C* is *D*, you must also deny that *A* is *B*, because the validity of *A* being *B* is implicated in the validity of *C* being *D*. "This man is fit to travel; therefore this man has not a fever." This is the Destructive Conditional Syllogism.

75. "But if you affirm the *Consequent* or *deny* the *Antecedent*, you can infer nothing; for the same Consequent may *follow from other* Antecedents, e.g. in the example above, a man may be unfit to travel *from other* disorders besides a fever; therefore it does not follow from his being unfit to travel, that he has a fever; or (for the same reason) from his *not* having a fever, that he is *not* unfit to travel." These two modes of unwarranted inference correspond to the illegitimate employment of causal evidence, noticed by Mr Mill as the error arising from Plurality of Causes. The student will see in Part II. Chap. I. 6, the close parallelism between the form of the process exhibited in the Conditional Syllogism, and the causal dependence of natural phenomena*. The form of the Destructive Conditional Syllogism is much employed by Euclid as a mode of indirect proof. "If the centre of a circle is not in a given line, it must be somewhere else, but, this is shown to be impossible, therefore it must be in the given line." If *A* is *B*, *C* is *D*, but it can be proved that *C* cannot be *D*, therefore *A* cannot be *B*.

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* The Conditional Syllogism does not only reason from the causal dependence of the propositions enunciated, but it also expresses an inference founded on the connection between a sign or symptom and the thing signified, as "if this man's pulse is unusually rapid he is feverish." Here the acceleration of the pulse is not the cause, but the symptom of the disease—the *ratio cognoscendi*; not the *ratio essendi*.

If the antecedent clause in a Conditional Syllogism be limited to a single possibility by the word *only*, we could make four instead of two valid inferences from the conditional premiss. Thus, supposing we were to say, *only* if *A* is *B*, *C* is *D*, then we must allow that if *A* be not *B*, *C* cannot be *D*, and again if *C* is *D*, *A* must be *B*. This is equivalent to assuming in the reasoning from effect to cause, that only *one* cause was in existence which could have produced the given effect.

76. A Disjunctive Proposition is one that consists of two or more Categoricals, connected by the conjunctions "either" and "or," the force of which is, to *state an alternative;* i.e. to imply that *some one* of the categoricals thus connected must be true, but *that all cannot be;* e.g. either "*A* is *B*, or *C* is *D*" will not be a true proposition unless one of the two members of it be true, but not both. If, therefore, one or more of these categoricals be denied (i.e. granted to be false) you may infer that the remaining one, or (if several) *some one* of the remaining ones, is true, and conversely, if *one* or *some* one be granted to be true the rest must be allowed to be false. E.g. "It is either spring, summer, autumn or winter, but it is neither spring nor summer, therefore it is either autumn or winter." Or, "It is spring or summer, therefore it is not autumn or winter." It must be noted that for a Disjunctive Argument to be possible, the members of the Disjunction must be mutually exclusive. Otherwise the rejection of one alternative will not imply the acceptance of the other, e.g. suppose we say "books are either instructive or amusing," it does not follow that because they are not "instructive" they are "amusing," or, that because they are "instructive" they are not

"amusing;" they may be both or neither. For the Disjunctive Proposition therefore to be formally available as a premiss, it must involve a positive and privative conception, according to the principle of Dichotomy.

77. The Dilemma is a complex kind of Conditional Syllogism thus described by Whately. "If you have in the *Major* Premiss *several antecedents* all with the *same consequent*, then, these Antecedents, being (in the minor) *disjunctively granted* (i.e. it being granted that *some one* of them is true), the one *common consequent* may be inferred, (as in the case of a simple Constructive Syllogism:) e.g. if *A* is *B*, *C* is *D*; and if *X* is *Y*, *C* is *D*, but either *A* is *B*, or *X* is *Y*; therefore *C* is *D*." "If I evict my tenant he will not pay his rent; and if I do not evict him he will not pay his rent; therefore I shall not obtain my rent on either condition." But if the *several antecedents* have each a *different consequent*, then the Antecedents, being, as before, disjunctively granted, you can only *disjunctively* infer the consequents; e.g. if *A* is *B*, *C* is *D*, and if *X* is *Y*, *E* is *F*; but either *A* is *B*, or *X* is *Y*, therefore either *C* is *D*, or *E* is *F*. "If Æschines joined in the public rejoicings, he is inconsistent; if he did not, he is unpatriotic: but he either joined or not: therefore he is either inconsistent or unpatriotic." This case as well as the foregoing is evidently *constructive*. In the Destructive Form, whether you have one Antecedent with several Consequents, or several Antecedents either with one, or several Consequents; in all these cases if you deny the *whole* of the Consequent or Consequents, you may in the conclusion deny the *whole* of the Antecedent or Antecedents, e.g. If this man is Sir Roger Tichborne he will recognize Sir Roger Tichborne's ac-

quaintances; if this man is not Arthur Orton he will *not* be acquainted with Arthur Orton's friends; but he does not recognize Sir Roger's friends and he is acquainted with Arthur Orton's friends; therefore he is not Sir Roger Tichborne, and he is Arthur Orton." This, however, as Whately observes, is not a true dilemma, but a combined pair of Destructive Conditional Syllogisms. "The true Dilemma is, *a Conditional Syllogism with several antecedents in the major, and a disjunctive minor*." The real *destructive Dilemma* is that which has (like the constructive ones) a *disjunctive minor Premiss*, i.e. when you have several Antecedents with each a different Consequent; which consequents (instead of wholly denying them, as in the case above) you *disjunctively* deny; and thence, in the Conclusion, deny disjunctively the Antecedents: e.g. if A is B, C is D; and if X is Y, E is F; but either C is not D, or E is not F; therefore, either A is not B, or X is not Y. "If a man is prudent, he will not do evil deliberately; and if a man is strong, he will not do evil impulsively; therefore, if he does evil, he must be either foolish, or weak."

78. An Enthymeme is a Syllogism with one Premiss suppressed. As all the Terms will be found in the remaining Premiss and Conclusion, it will be easy to fill up the Syllogism by supplying the Premiss that is wanting, whether Major or Minor: e.g. "Cæsar was a tyrant; therefore he deserved death." Here, the premiss suppressed is the *Major:* "All tyrants deserve death." "A free nation must be happy; therefore the English are happy." In this example the *Minor* Premiss is understood, viz. "the English are free." All ordinary discourse abounds in Enthymemes, or tacit assumptions, and it is

one of the most useful exercises in Logic to examine an argumentation as usually set forth, in order to elicit the latent premisses, and test the validity of the inferences. For, as Whately remarks, the Enthymeme is *not strictly syllogistic;* i.e. its conclusiveness is not apparent from the mere form of expression, till the suppressed Premiss shall have been, either actually or mentally supplied. The expressed Premiss may be true, and yet the Conclusion false.

79. "The Sorites is a string of Syllogisms, in the first figure, in which the Conclusion of each is made the Premiss of the next, till you arrive at the main or ultimate conclusion of all. The Predicate of the first proposition is made the Subject of the next; and so on, to any length, till finally the Predicate of the last of the Premisses is predicated (in the Conclusion) of the Subject of the first: e.g. *A* (either every *A*, or some *A*) is *B*, every *B* is *C*, every *C* is *D*, every *D* is *E*; therefore *A* is *E*; or else no *D* is *E*, therefore *A* is not *E*. The English are a brave people; a brave people are free; a free people are happy, therefore the English are happy." A Sorites, then, has as many Middle Terms as there are intermediate Propositions between the first and the last; and consequently, it may be drawn out into as many separate Syllogisms; of which the first will have, for its *Major Premiss*, the *second*, and for its *Minor*, the *first*, of the Propositions of the Sorites; as may be seen by the example. "In a Sorites the *first* proposition, and that alone, of all the premisses, may be *particular;* because in the first figure the Minor may be particular, but not the Major; and all the other propositions prior to the Conclusion, are major premisses. It is also evident that

there may be, in a Sorites, one, and only one *negative* premiss, viz. the last: for if any of the others were negative, the result would be that one of the Syllogisms of the Sorites would have a *negative minor* premiss; which is (in the first Fig.) incompatible with correctness."

The Sorites is adapted to exhibit trains of reasoning, and the process of *piecing* together evidence or inductions, see Mill's *Logic*, Book II. Chap. IV. § 2.

PART II.

LECTURE I.

LAWS OF NATURE.

1. THE succession of events in external nature occurs in a constant uniform order and connexion. By becoming acquainted with this order and connexion, man is able to control these events, and in some measure to anticipate, imitate, or frustrate them. Thus through such knowledge he is converted from a slave, into a master, of nature. *Inductive Logic has for its object the investigation of the processes of reasoning by which the processes of nature are tracked and her mysteries unveiled.* Nature on ultimate analysis is a number of elementary forces, energies, or powers, capable of effecting changes, either when acting singly or in combination. A group or aggregate of such powers or forces either permanently or temporarily combined is termed an object, and these constituent elements, powers, or energies are the properties of objects. Objects are therefore a combined set of natural forces capable of exercising an influence on other objects with which they may be brought into rela-

tion. All the processes of nature, the sequences of events, and the eternal changing panorama of the universe, are produced by the action, reaction, and interaction of objects or groups of elementary forces. *The intrinsic property or potency of each elementary energy is constant and uniform in its operation.* It is liable to be neutralized or suspended when acting in concert with others, but its native capacity although disguised is still existent or militant. The consequence of this uniformity, constancy and identity in the mode of operation of natural agencies is a corresponding uniformity, constancy and identity in the natural processes or series of events of which these agencies are the source and origin. The energies of nature being identical in their operation, the processes into which they enter as factors or elements will naturally present a certain degree of uniformity. Sequences of events will occur and recur in cycles or orderly series, one or more links of which being known the rest may be predicted. These orderly and uniform processes of natural phenomena are termed laws of nature. *A law of nature therefore is any regular and constant process, sequence, or mode of operation of natural agencies.* The phenomenon we call Fire or combustion is a natural process into which enter two elementary gases or natural agencies, Oxygen and Carbon, endowed with certain properties or modes of operation disclosed under certain conditions. These modes of operation are themselves laws, since their action is uniform, and the processes into which they enter are also laws, since uniform agencies produce uniform processes. The process of combustion is therefore a law of nature, and the statement embodying or expressing this law is the proposition "*all fire burns,*" which merely gathers up into one enunciation the past, present, and future behaviour of certain constant and fixed natural agencies, powers, or capacities, when brought into identical relation to each other.

Uniform agencies produce uniform processes. The sun has the property of radiating heat and light in definite quantities to definite distances. All the particles of which the earth is composed have the property of attracting other particles with an energy measured by the inverse square of their distance, and of also being attracted in the same manner. From the constant and identical action of these powers in Sun and Earth, there results that infinite variety of changing phenomena, those series and cycles of events which we call the Seasons. Thus from the combined operation of two or three elementary attributes, powers, properties or agencies, there arise those uniformities of more or less complexity, those cycles of events and changing phenomena recurring in fixed order, which we call laws of nature*.

2. *The ultimate aim of human knowledge is to ascertain the mode in which natural agencies will behave under given conditions.* This mode of behaviour is called the law of their operation. The aim of Science then is to discover the law of the operation of natural agencies, either acting singly, or in combination. In considering the uniform processes of nature or chains of events, it would seem

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* The Duke of Argyll says that the fundamental conception of Law is an ascertained working sequence or constant order among the phenomena of nature. *Reign of Law*, chap. II. According to Kant, the laws of nature are the fixed relations of objects apprehended in a similar manner by all intelligences under similar circumstances.

that each link in a series is necessary to the production of the next following in order of time. We give the name of Cause to this antecedent link, and the name of Effect to that which succeeds. We ascribe to the antecedent link the power of producing the consequent, or in other words we assume that the consequent is a necessary result of the operation of the antecedent. *Law is therefore a constant exhibition of the sequence of cause and effect;* the Cause being the united or concomitant action or interaction of two or more natural agencies; the Effect being the resulting phenomenon which is itself a new aggregate of natural agencies ready to enter into combination or united action and become the cause of some new effect. Thus to revert to our former illustration the joint agency of the gases Carbon and Hydrogen results in the production of a phenomenon which is the agent we call fire. This fire again is itself an agent capable of entering into combination with other agents and becoming a cause, part of a cause, or link in a sequence, for the production of new effects. *A cause then is an aggregate of natural agencies* whose interaction gives birth to a new phenomenon called an effect, incorporating these same agencies in a new mode of combination. A law is the successive action of causes in a series of phenomenal changes.

3. *It would thus appear that the ultimate aim of Science must be to discover the capabilities, powers, or modes of behaviour of simple, primary, elementary, natural agents under definite conditions, or when brought into definite relations to each other.* But the fundamental properties or potencies of natural agencies are not generally disclosed to immediate observation. The phenomena of nature with

which man is directly environed are effects due to the united action of agencies, which therefore have to be analyzed into their constituent elements, before a knowledge of the primary properties of simple agents can be obtained. The spectacle of a course or cycle of natural events does not suggest the possibility of their regularity order and rhythm being due to the sustaining operation of some few natural elementary agents. When Kepler marked the elliptic orbits of the planets, the periodic times, and other laws or uniformities which they exhibited, he probably did not suspect that the universal tendency of matter to gravitate was the prime causal factor or agency at work behind the whole panorama. It is true that the ancients seem to have had a lurking suspicion that the complicated but orderly processes of nature may owe their production and maintenance to the continuous operation of some occult energy, hence the futile researches after such things as the elixir of life, the philosopher's stone, perpetual motion &c. But it has been reserved for the present age distinctly to realize the conception of elementary properties susceptible of experimental verification.

4. *The Efficiency, Active Principle, Potency or Working Energy of every elementary natural agent is constant, uniform, and identical.* The Carbon of to-day does behave in the same way under assignable conditions as the Carbon of yesterday or a thousand years ago, and what is more important to Human Beings, will behave the same in the future as it always has in the past. It may be asked on what grounds we believe this wide reaching generalization? The reply is, *a thing is what it does, or what it is capable of doing, which is proved by what*

it does. In other words the nature of a thing is defined by its mode of manifesting its activity. *Essence is Agency.* If this conception of existence be admitted, the immutability of elementary properties becomes a necessity of thought, as well as a fact of nature. If Carbon has its distinctive and identifying attributes defined by its mode of behaviour when subjected to assignable conditions, then if those characteristic properties failed to manifest themselves when called upon to do so, we should not consider that the original element termed Carbon had lost its energy or virtue, but we should be constrained to think that this element Carbon did not exist, or was not in evidence, on the given occasion. Once conceive, admit, or realize that the behaviour of a thing is a test of its identity, then we shall be compelled to say that the *thing is something different when its form of activity is different.* This paramount truth should be, together with its corollaries, constantly recognized, and distinctly expressed. One of the most important consequences flowing from this principle is that *no agent or group of agents has any intrinsic power of changing itself, or modifying its own properties.* All alteration in phenomena must arise from the interaction of elementary agents. Whenever a change is effected in a given set of elementary agencies, it is an infallible token and proof that some new agency has come into operation,—has combined its power with the original set,—and that their joint action has resulted in the production of a new phenomenon. Newton enunciated this all-pervading fact or Law in respect to the change of position in space wrought in any aggregate of material particles. He affirmed in his first law of motion that a body had no power in itself to change its state of rest, or rate of velocity. This principle is only a particular case of the universal axiom that the manifested activity or mode of energy of any elementary finite agent or group of agents can only be changed, altered, or modified by the influence of some external, foreign, or new agency. This universal fact is generally summed up, expressed, and embodied in the statement that "*every effect must have a cause.*" This maxim we now see is not the enunciation of a primary truth, but is a necessary corollary from the conception of identity of Being as constancy of operation which we have so often reiterated. It is for Science to determine how new agencies combine and enter into union or the sphere of operation with others. Proportionate combining quantity, spatial contiguity, and elective affinity bring about changes in sets of agents, or in other words create new effects. The agency termed Gravity is a power which seems to operate throughout the universe with intensity determined by distance. Mr Mill distinguishes the combining processes of natural agencies into two kinds, one where the resultant or produced agent is of the same kind as the component factors which produce it, or in other words where the effect as an agent has the same properties as the co-operating causes. This is generally called mechanical combination, and is really the effect of the addition of a number of like powers, whose sum or whole is therefore not different to its constituent parts. But there is another species of union into which natural agents enter. This is in the case where the factors are not of the same kind, and where the resultant compound is a new agency different to its constituent elements. Water, for example, has for its chief ingredients Oxygen and Hydrogen, but the properties of Water are different from those of either Oxygen or Hydrogen. This sort of fusion is called chemical combination; there is only one kind of natural agency which is susceptible of mechanical union, viz. that kind of energy known as force, the property of which is to overcome resistance and create motion. Properly speaking, the principles of inductive Logic are only applicable to the inquisition of phenomena under their chemical aspect.

5. The two most universally present facts in nature we have seen are the identity in the mode of operation of natural agents, and the causal necessity of change. These correspond to the principles of identity and sufficient reason, noticed as Laws of Thought by logicians. The principle of identity is indeed a necessity of thought, or a necessary mode of apprehending the being of things. *Things are what they do, and when they act differently they become different*, but as their identity must subsist intrinsically, *all change must depend upon the interference of something extrinsic*, in other words, no change can take place without sufficient reason, or cause, or alien agency. Every effect must have a cause, every change must have a sufficient reason to account for it, this is the instinctive dictate of common sense in common life resulting from the evidence of uncontradicted experience. This is the ground of the belief in the absolute universality of causation, which those are content to adopt who will only admit experience as the criterion of truth. But the evidence of experience itself depends for its cogency on the higher principle of identity which we have noticed. Nature's modes of operation are identical.

6. It will contribute to the elucidation of the subject

if we enumerate the chief aspects under which the principle of causation may be viewed in the discussions of Inductive Logic. 1. Every effect must have a cause. 2. The same cause will always produce the same effect. 3. If the cause is present the effect must be present. 4. If the effect is absent the cause must be absent. 5. If a given cause is absent it does not follow that a given effect need be absent. 6. If a given effect is present it does not follow that a given cause need be. The reason of these propositions is sufficiently obvious from what we have already stated with regard to the principles on which the processes of nature are established. The first two are manifestly the principles of sufficient reason and identity respectively; the third and fourth are self-evident, mere statements of the activity of physical phenomena.

7. The two latter statements rest upon the assumption that it is competent for the same effect to be produced at different times by different sets of causes or agencies, so that the non-presentation of any given set of causes does not imply that an effect would not happen which would have happened if the given set of causes had been present. If two or more sets of causes could produce the same effect, it does not follow that the absence of any one set of causes would necessitate the non-occurrence of the effect. The roads may be wet although it has not rained, because a water-cart may have produced the same result. Similarly it is impossible to argue from the existence of any effect to the set of agencies which produced it; if we find the roads wet, one cannot say whether the proximate agency at work has been a water-cart or a shower. This condition

of causal reasoning is termed by Mill plurality of causes. If admitted as a valid aspect of the Logic of Induction it vitiates entirely any evidence grounded on effect simply. That is to say, *from the observation of phenomena barely, we can argue nothing historically concerning the processes, series of events or chains of agency which may have concurred to their production.* The only condition on which the argument from effect to cause is valid, is the absolute certainty that the effect could only have been produced by one given set of agents. Otherwise the ascription to one out of many possible modes of production can only be hypothetical. The importance of this consideration cannot be overrated, as the neglect of it leads untrained minds to place on the same level of proof, and to consider as equally cogent, two kinds of evidence whose force differs to the extent of one being the strongest and the other the weakest possible.

8. The argument from cause to effect is perfectly irrefragable, that is to say, when a given effect has been brought into being by the observed operation of a set of assignable agencies, the necessary connexion of such cause and effect is according to our previous remarks absolutely unimpeachable. But on the other hand, if we admit the possibility of plurality of causes, the argument from any phenomenal effect to the agency which may have produced it varies in validity according to the number of possible causes which may have been in operation; and if these are infinite, the value of the evidence is zero. All kinds of proof called theoretical, hypothetical, historical, and genetic are liable to this infirmity, and unless their weakness can be compensated for by collateral sources of evidence, they afford no

absolutely valid basis of belief, but only a more or less high degree of probability. In forensic cases, what is called circumstantial evidence, upon which the life of a human being on trial for murder often depends, partakes mainly of this hypothetical character. Many a miscarriage of justice has been hazarded by a clever advocate springing on a jury a vivid, coherent, and consistent theory of the series of events of which the crime was the final outcome. *To undisciplined minds the plausible recital of the mode in which an event might have happened, is almost equivalent to a proof that it did so happen.* In the recent trial of O'Donnell for the murder of Carey the Approver, the counsel for the defence wove such a consistent theory of events and circumstances (which if they had happened would have made the act one of self-defence) that the sense of the jury was for a moment completely obscured, and they were only recalled to a rational estimate of the aspect of the case by the Judge reminding them that there was not a particle of evidence to show that any single one of the events or circumstances recounted by the counsel for the defence had ever been in operation. To convert an hypothesis into a proof, it is absolutely necessary to be able to demonstrate two things, 1. *That a certain set of agencies if operating would produce a given result.* 2. *That they actually have been operating.* Now the untrained intelligence attributes much more importance to the first than to the second element of proof, so much more indeed, that the latter is often dispensed with altogether, or is not called into requisition until the jealousy of rival hypotheses demands corroboration for one theory rather than another. It is true that Science could make very little progress without hypotheses, they give point and method to researches into the labyrinth of natural processes. There are, however, *two* distinct kinds of scientific enquiry, in *one* of which hypotheses must always remain in the region of probability, in the *other* it is possible to convert hypotheses into facts and probability into certainty.

9. There is a group of Sciences occupying the most important field of human research known as *Experimental Sciences*, in which the phenomenon or effect to be accounted for can be actually reproduced at will, and hence the agencies adequate to its production can be discovered. In other words, the active properties of natural agents can be made to display themselves once and for all, since by the principle of identity what a thing is capable of doing once it is capable of doing always. *The business of Inductive Logic is to establish rules by which the value of the evidence furnished by experiment as to the character of natural agents may be tested. Experiment is the artificial creation of experience*, experience is the actual perception of a natural process, consisting of the sequence of cause followed by effect. Experiment therefore can only be applied to the phenomena of change or succession. Co-existent phenomena are not amenable to evidence afforded by experiment, and are not susceptible of any precise verification, but as we shall see afterwards merely reach a degree of probability dependent upon a number of instances observed. The proposition that "*all crows are black*," which asserts the co-existence of a black colour with the other attributes of a crow, was once thought to be the type of an inductive generalization gathered from the experience of particular instances. Until the discovery of Australia the truth

of this proposition was considered absolute and universal. Now, however, there have been discovered in that Continent birds with all the other marks of crows, but of a white color. Hence the inductive generalization is imperfect. The reason is, that such a generalization cannot be reduced to the principle of causality, and therefore can never be capable of absolute verification. This point is important, and should be thoroughly grasped before further progress is made in the subject.

10. All the phenomena of nature are either groups of co-existent attributes termed objects, in which the energies or natural agencies appear to exist in a kind of statical equilibrium balancing and neutralizing each other and exhibiting a kind of permanence or stability—or they are events, stages of change, in which the co-existing attributes of objects are resolved and dissipated, again to reform into fresh phenomena under the action of elementary forces. It is often thought that the constitution of objects must be dependent upon causal agency in the same manner as the stages of change or the succession of events. The structure and function of organized beings have however of late years been subjected to a revised scrutiny under the light shed by the theory of evolution, which has been a veritable Novum Organum in the researches of modern science. According to this doctrine, development, not causation, is the proximate object of investigation in the permanent classes of co-existent phenomena designated plants and animals. The connection of development with causation, agency, or energy is a very subtle problem not yet probed, and scarcely recognized, belonging to the province of Metaphysics rather than Logic. The idea of Causation

as the instrument and ground of induction by experiment is not applicable to the phenomena of co-existence in nature, that is, no conclusions can be arrived at as to any necessary connexion or relation between the parts, organs, qualities, attributes or properties of the various classes of phenomena making up the total of organized existence. We say that horned animals are ruminant, because, we find this to be the case with every species of horned animal which has come under our observation. Evolution may further tell us that hornedness and ruminancy are parallel modes of development necessarily differentiated through some primordial potentiality. But we cannot perceive causal agency at work, we cannot detect the *beginning and end* of a change, which is the absolutely indispensable requisite of experiment, or creation of artificial experience. Organic beings grow and develop, but we cannot make them do so at our pleasure, we cannot experiment with them, we cannot control the beginning and end of change, and until we can, we have no valid inductive evidence upon which to base inferences. *Experiment is the creation of an artificial experience of a change wrought under our observation.* We must be able to know the precise antecedent state of a phenomenon, the elements which are present constituting this state and the circumstances under which it exists, and then we must know besides accurately the state of the same phenomenon consequent upon the introduction of some disturbing agency. *The elements constituting the antecedent state of this phenomenon together with the disturbing agency we call the Cause,—and the consequent state determined by the coefficiency of all the operating agencies, we call the Effect.* Experiment therefore must involve a change, an event, a succession, both terms of which are amenable to immediate observation. From the evidence thus afforded the active properties of natural agents can be with certainty detected, and the law, that is, the constant tendency of their operation may be ascertained.

11. The word Experience is by many loosely and vaguely identified with Induction, that is to say, the Inductive inference is said to be based on experience, while experience and experiment are considered synonymous. Experience, however, is a much wider meaning term than experiment. Experiment is, as we have said, the creation of artificial experience, but the immense preponderance of experience, in the ordinary sense of the word, consists of the passive reception of the fleeting impressions of sense, which are stored up with more or less fidelity in the memory. Now these impressions are themselves effects of which the antecedent causes are not generally accessible to superficial observation. Unless therefore some method of carefully testing, sifting or corroborating the evidence furnished by the senses is adopted, the records of bare experience however faithfully registered in the memory afford no trustworthy data for scientific inference. Experience tells us that two events have succeeded each other, or that two properties coexist in every member of some species of organized existence. The constancy of the conjunction is to ordinary minds the warrant of their causal connexion, and the strength of this belief is always proportionate to the observed frequency of the coincidence. Frequency of conjunction therefore is really made the test of causal connexion, and constitutes the argument from experience, the data of inductive inference. We have already seen

that in its crudest form this kind of evidence has no weight whatever, is in fact the same as the old logical fallacy of "Post hoc propter hoc." *Experience pure and simple is no valid ground of inference, and experience alone is not the basis of scientific knowledge, it is only that kind of experience experiment creates which is really the justification of prediction arising from a belief in the identical operation of natural agencies.* Kant probed the true nature of experience, and the kind of experience upon which scientific, that is, predictive knowledge was based. As an instance of such knowledge he adduces the example of a physicist, who can make a ball of given weight roll down a plane with a calculable velocity, by adjusting the angle at which the plane is inclined to the horizon.

12. All experience then is not experiment, although experiment is a species of experience. Experiment can only be applied to phenomena of succession, not to phenomena of coexistence. Causal connexion can only be proved by experiment, and the active properties of natural agents can only be discovered and tested by the mode in which they manifest themselves in the causal process. These principles are so simple and obvious that they seem hardly worth the trouble of stating. Most writers on Inductive Logic accordingly assume them as the background of their reasonings on the subject. Hence they are often overlooked by the student in consequence of their not being noticed by the author. There is nothing recondite or peculiarly characteristic of scientific procedure in experiment, the unsophisticated mind has ever appealed instinctively to this mode of proof, and embodied the rule in the proverb, "The proof of the

pudding is in the eating," or "A burnt child dreads the fire." It was the humble pretensions of the method of experiment, and its perpetual adoption in the circumstances of common life, that probably prevented philosophers and scientific men during so many ages from recognizing and enunciating the absolute and indispensable necessity of basing all precise knowledge of the powers of natural agents on experience verified by experiment. The genius of Bacon is supposed to have directed the attention of the learned to the value of experiment in proving causation. What, however, contributed most to obscure the ancient methods of research, and is now somewhat confusing in the logic of discovery, is the fact, that experiment, although the ultimate final and fundamental stage of investigation, is not generally the initiation or commencement of the process. *Discovery must commence with the observation and detection of laws*, and these laws are not amenable to experimental methods.

13. The term Law is applied to two different kinds of activity. Those which Mr Mill terms laws of nature are the ultimate properties or energies of natural agents, permanent in their nature, constant in their operation, such as gravitation. But it is seldom that the activity of an elementary agent can be detected by simple observation; such activity combining with the activities of other natural agents may present itself under manifold disguises, which it is the aim of science to penetrate. But a thing is what it does, that is, the activity of the thing is the thing itself, *the law of anything is its active property or operating tendency.* Such laws then are not patent, but have to be disengaged from those with which they are compounded.

Secondly, the word law is applied to the uniformities of action *exhibited* by natural phenomena. These uniformities are not latent or occult tendencies or potentialities, but patent positive overt manifestations, such as the law of the Planetary motions. It is obvious that these laws which are open and manifest in their operation must offer themselves earliest for discovery. Patient observation and accurate registration are the only methods requisite for their ascertainment. In the last half century these methods of observation and registration have been brought to a high degree of perfection; especially has the idea been successfully applied of noting cycles and periodic changes by means of geometrical curves. The principle of continuity, which assumes all changes in nature to take place through insensible gradations, corresponds to the conception in Geometry of a curve made up of infinitesimally small points. Hence any change can be adequately represented by a curve, and the geometrical properties of such a curve will often assist in the investigation of the laws of physical changes, or prove that such laws exist where least suspected. Some writers think that the chief part of the logic of induction consists in the improvement and extension in the methods of discovery, which have proved so singularly serviceable of late. *But the laws, the discovery of which these methods are designed to facilitate, are the laws which phenomena exhibit*, not the laws of the being or ultimate properties of things, which Science must hold chiefly in view. Kepler discovered the laws which celestial phenomena exhibit, but it was left for Newton to detect the universal law which constitutes the fundamental attribute of all matter. The laws which phenomena exhibit and which are primarily open to observation and discovery, but which are not primary modes of being, Bacon designated "Axiomata Media," and the distinction between Dr Whewell's and Mr Mill's views of the objects of Inductive Logic seems to be, that the former makes the business of induction the examination of methods of discovering these middle laws by observation and registration, while Mill analyzes the process of experiment as affording the necessary evidence in the proof of the primary properties of things. There need be no opposition in the scope of the subject recognized by these eminent thinkers. Mill's Methods of Experiment are not very comprehensive in their range of exact application, and they labour under the reproach attaching to the rules of formal Logic, viz. that of examining a process, which the ordinary mind performs instinctively every moment without knowing or caring how or why, and which no amount of investigation will improve or facilitate. Whewell's rules on the other hand are of real assistance to the observer by depicting law under visible forms.

LECTURE II.

METHOD OF DIFFERENCE.

14. By means of experiment we endeavour to make some natural agent disclose its nature in displaying its Causal Efficiency. Mr Mill has formulated the mode in which such evidence is obtained under the name of the Method of Difference. This with four other processes he constitutes the chief means by which the data for Inductive Inference are collated. These five methods as stated by Mr Mill are, 1. The Method of Agreement. 2. The Method of Difference. 3. The Joint Method of Agreement and Difference. 4. The Method of Concomitant Variations. 5. The Method of Residues. Of these five methods, it seems admitted by Mr Mill that the Method of Difference is the only one capable of furnishing direct proof of the actual operation of Causal Agency. And as according to our view it is only through Causal Efficiency that the active properties of natural agents are manifested, it follows that the Method of Difference is strictly speaking the only procedure by which the elementary energies of nature can be detected. In this method we witness a change actually operated under direct ob-

servation. Of this change we see the beginning, the end, and the proximate agent. The stress of the proof lies in the knowledge we have that the only causal agent which could possibly have produced the observed change is the one which we ourselves have introduced into the experiment. The mingling of a certain quantity of sugar with a cup of tea renders the liquid capable of producing on the palate the sensation termed sweetness, which previous to the introduction of the sugar it had not the property of doing. Here then is a change of which we perceive the beginning, the end, and the proximate agent. We know how the tea tasted previously to the insertion of the sugar, we are conscious of the change of flavour effected, and we are certain that the sugar was the only disturbing agency brought into play. The steps are: 1. We observe the phenomenon in a certain state, that is, we observe a set of natural activities constituting a stable group. 2. We mingle some foreign agency with this group. 3. We note a change or fresh constitution of all the activities in operation. By the principle of sufficient reason, already enunciated, we presume that this change could not have been effected without the direct and instantaneous agency of some disturbing cause, but we are assured that only one such interfering agency was in actual operation. Hence we legitimately infer that this one must be the proximate cause of the change. We may then appeal to the law of Identity, and confidently affirm that under like conditions a similar agency would effect a similar result. Hence we have obtained what is termed an Inductive generalization, a Law or uniformity of Nature, a possible mode of behaviour of a natural agent under given conditions.

15. In the process we have described the agent whose activity we wish to provoke is introduced into a group of other elements, and a change is observed consequent upon the presence of an alien activity. This is the most direct kind of affirmative evidence furnished by the Method of Difference. There is, however, a counter process amenable to the same principles, which consists in removing some constituent of a given compound and observing how the phenomenon is affected thereby. The object generally is to discover the cause of a present effect, as the procedure already described discovers the effect of a given impending cause. The reasoning is *mutatis mutandis* the same in both instances. We find that some phase of a given phenomenon vanishes with the abstraction of one of its elementary constituents. We therefore argue that the element removed must be a proximate agency in the production of the effect which has been destroyed. The effect originally existing must have been due to some present energy in actual operation, and the withdrawal of the effect can only be attributed to the extinction of the influence of the agent which has been eliminated, since no other possible agent can have intervened, and by the law of sufficient reason some activity must have ceased to operate if part of the total phenomenon disappears; in fact, a new effect has been produced by the absence instead of the presence of a proximate agent. Common experience abounds in examples of this process of inference. A man feels discomfort from some derangement of the digestive functions, and surmising that the cause must lie in some item of his diet, he forthwith proceeds to abstain from the supposed cause of the malady, the discomfort ceases,

and the natural inference is that the source of the evil was the article of diet which he has abandoned. The validity of the experiment depends upon the absolute certainty with which it can be ascertained that the agent which we have removed is the only element excluded. In the illustration given it is possible that the patient may have modified some other habit of his life, as well as have relinquished some kind of food. It would then be difficult to say which had been the real remedial measure. This may be called the inverse or negative application of the Method of Difference, but Mr Mill places it in the foreground as the type of the experimental method under its most characteristic aspect.

16. The Method of Difference last examined is that by which the causal dependence of co-existent phenomena may sometimes be proved. This is, however, only possible when one element of a group of co-existent factors can be detached and the consequences noted as above described. Thus the *connexion of co-existent phenomena is tested by reducing them to phenomena of succession, and making them amenable to experimental proof.* In many classes of cases however this disengagement of some factor of a total phenomenon is not attainable. There is in fact no reason *prima facie* to suppose that the co-existent parts of a phenomenon are of necessity causally connected, and whether the dependence is one of causation or not is the primary fact to be determined; parts of a whole may co-exist either in mechanical, organic, or causal union. Organic union means the dependence of parts of a whole through the whole. They co-exist and are coherent not directly, but as members of one body. When this is the case it is impossible to dis-

sociate one organic constituent without destroying the totality. This is a difficulty in physiological researches. The investigator cannot discover the connexion of the vital organs because he could not remove one of them without destroying the living organism. Hence the futility of endeavouring to establish universal laws of connexion between the constituent parts of concrete objects. *They must be capable of being reduced to phenomena of succession susceptible to experimental proof by the Method of Difference.* Suppose we wanted to prove that a certain kind of odour and colour were causally connected in flowers, how would it be possible to prove that these were causally connected? we could not remove either the smell or the colour.

17. The most salient feature of the proof of causal dependence derived from the evidence afforded by the Method of Difference is, that it does not rest at all on any ascertained frequency of conjunction; there is a rooted prejudice to the contrary which is entertained by most writers, although Mr Mill does not share it. *The cogency of experimental evidence is entirely due to the absolute knowledge we possess that an agency has been inserted or withdrawn at a moment of time so immediately antecedent to the creation or extinction of a certain effect that no other cause could possibly have intervened.* The entire reasoning upon which the inference rests is contained in the compass of a single instance, and no amount of repetition can add more evidence than is already attained. If it is advisable to repeat the experiment we do so in order to be certain that the process has been correctly performed. When phenomena are constantly observed to succeed each other in apparently inseparable conjunc-

tion, the belief is certainly engendered that there is a causal connexion between them, and Hume asserted that this constancy of succession was all that is meant by causation. The evidence afforded by frequency of conjunction lent colour to Hume's doctrine, but the experimental method of difference seems to show that mere succession does not constitute causation. All causation involves succession, but the act of experiment necessarily implies the conception of agency, and the competency or adequacy of the given conditions to bring about the given result. In a certain sense even the effect is not a consequent of the antecedents because they do not cease to exist when the effect begins to exist. In fact, the maintenance of the effect must depend on the permanence of the activity of the causes, "*Cessante causa cessat et effectus.*" Succession in itself is a mere phenomenal incident, and the first task which science has to perform is to determine when phenomenal succession does or does not involve causal dependence. This is to ascertain what Mr Mill calls "unconditional antecedence," which we suppose to mean that if the antecedent failed the consequent would also be wanting. Such a test can only be applied through the method of difference which can remove or reinstate an antecedent at will. Indeed by the experimental proof it is not succession only which corroborates the suspicion of causal union; but as we have seen the final appeal is to a general maxim respecting the uniformity of nature. The common refutation of Hume's view that causation is mere succession is, that by this doctrine day may be called the cause of night. But this does not exactly attack the position of Hume because he would have been perfectly ready to admit that all succession is not necessarily causation; what he affirmed was that when causal efficiency was said to have been operating nothing but succession had ever been observed. But *when a change was reduced to an experiment by the method of difference, would he still have persisted that nothing but succession was discernible?*

18. Hume's attempted identification of succession and causality roused Kant to the investigation of the whole subject of Causation. Kant, like Hume, found succession, or the time element, to play a very important part in our conception of phenomenal change, but Kant thought that *fixity of order was the essential characteristic of objective causation.* According to his well-known illustration we may think of the top of a house first, and then of the foundations, or the thought of the foundation may precede the thought of the top; but, turning to the objective fact, the house as a causal series, we are necessitated to conceive the sequence of changes which determined the being of the house as having happened and only being able to happen in one fixed irreversible order. This order of springing into being may have been from the foundation to the roof, or even from the roof downwards, but one or other it must have been, and could not have been both. Like the logical laws of contradiction and excluded middle, which affirm that a thing must either have one or the other determination but not both, so agency, causality, efficiency, or activity, must manifest itself in one or other of a fixed order of sequence, but not in both. This Kant makes the criterion between ideality and actuality, between the thought of the thing and the thing itself, between the imagined and

the real. The thought of to-day may suggest the thought of the events of yesterday, or thinking of yesterday the mind is carried forward to the present time, *the order in thought is indifferent, but the order in occurrence, in fact, in reality, is single and definite.* Yesterday must precede to-day, and we cannot imagine even Omnipotence reversing the process. The cause must precede its effect and cannot be conceived as happening otherwise, although it is indifferent whether we think of the effect or the cause first, as mere modes of consciousness. Kant hence maintained that from the mere subjective ideal or reflective consciousness we should not be able to acquire the notion of time as an objective fact. The notion of time is engendered by the perception of causality. The successive instances of time occur in fixed irreversible order. *But such order is as we have seen not a necessity of our thought about things but a necessity of things themselves, or rather not a necessity of our thought of events but a necessity of the events themselves.* So Schopenhauer seems to misunderstand another of Kant's favorite illustrations of the same idea. Kant says we can only *perceive* a boat floating down the river in one direction and passing successively point after point, but we may *imagine* the same boat with equal facility floating up the river. What Kant meant was, that the boat must have done or be doing either one or the other.

"The ship was cheered,
The harbour cleared,
Merrily did we drop
Below the kirk, below the hill,
Below the lighthouse top."

Kant meant that the progress of the ship was in a fixed order, determined by the fixed positions of kirk, hill and lighthouse, which order as an objective fact of occurrence, an event, or *fait accompli*, was irreversible and fixed.

19. Causality therefore can only manifest itself in an assignable order of time, and the evidence afforded by the observation of a causal process must involve an element of time, a change, a before and after, a succession, the terms of which are distinctly cognizable. Mr Mill, although he generally seems to take this view of Experiment as exhibited in the Method of Difference, does not accentuate or emphasize the time element necessary to the due exhibition of the method. He describes the process as follows: "If our object be to discover the effects of an agent A, we must procure A in some set of ascertained circumstances, as ABC, and having noted the effects produced, compare them with the effect of the remaining circumstances BC, when A is absent. If the effect of ABC is abc, and the effect of BC, bc, it is evident that the effect of A is a. So again, if we begin at the other end, and desire to investigate the cause of an effect a, we must select an instance as abc, in which the effect occurs, and in which the antecedents were ABC, and we must look out for another instance in which the remaining circumstances bc, occur without a. If the antecedents, in that instance are BC, we know that the cause of a must be A: either A alone, or A in conjunction with some of the other circumstances present," and the canon runs thus—"[*] If an instance in which the phenomenon under

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[*] Mill, Book III. chap. 8.

investigation occurs, and an instance in which it does not occur, have every circumstance in common save one, that one occurring only in the former; the circumstance in which alone the two instances differ, is the effect, or the cause, or a necessary part of the cause, of the phenomenon." Hence we see that neither in the formula of the process nor in the canon is it distinctly enunciated that the gist of the whole proof is the activity of the agent manifested in the production of a change. The word "instance" is ambiguous in signification, and it is not obvious that there are not two contemporaneous instances meant which differ by only one circumstance, instead of *two successive stages of the identically same Instance, and that it is transition from one stage to another wherein the stress of the proof rests.* Yet Mill evidently intends this by his illustration, "When a man is shot through the heart, it is by this method we know that it was the gun-shot which killed him; for he was in the fulness of life immediately before, all circumstances being the same, except the wound." In this example the identity of the circumstances in the two instances is insured by taking an organism at two stages, one before and the other after the introduction of a foreign agent. Hence the effect can only arise from the activity of the new agent.

20. The ultimate aim of Science is to acquire the power of prediction. The present is the material of feeling, the future is the sphere of knowledge, hence it is highly important to consider what conclusions respecting the future may be drawn from the evidence of the present furnished by the Method of Difference. We witness the actual change wrought in a group of phenomena by

the intrusion of an alien agency, or we observe the modification which ensues on the withdrawal of some constituent element. These changes are facts, their occurrence cannot be gainsaid, the question is, what warrant does this evidence afford of their recurrence? All general propositions are of the nature of prophecy, they transcend experience, in so far as experience only teaches what has happened and not what will happen. This leap from the past and the present, to the future, is the inductive jump that Mr Mill speaks of, —the justification for which Kant sought to discover in the nature of human reason and the conditions of human knowledge. An Inductive generalization is a statement about some relation of things which based on the evidence of observed facts asserts something respecting facts which have not yet been observed. In the Causal process exhibited by the Method of Difference we see an agency at work effecting a manifest result. When this agency is again in operation, what assurance have we that a similar result will follow? By the principle of the uniformity of nature, which we have termed the law of identity, we can confidently predict that if all the present conditions of the experiment are undeviatingly repeated, the entire process will unerringly recur. This is almost tautological, but it is equivalent to stating that an Inductive generalization may be inferred from the manifestation of causality elicited by the employment of the Method of Difference. Could we then affirm (to adduce Mr Mill's illustration) from the death of a man by a bullet in his heart, that such a cause would always produce a similar effect, or that every man with a bullet in his heart would die, the answer would be that so long as the human organism remained constituted like that upon which the experiment was tried, the same result would follow, and the generalization would be justified. So far, then, the judgment grounded on the observation of causality is universal, contingently however to the realization on all future occasions of the conditions existing at the moment of the experiment. Hence the generalization is subject to a condition, is therefore not absolute but contingent. Again, the evidence of the Method of Difference is obtained by a collocation of circumstances artificially combined. Over the recurrence of such a combination it is obvious that no verdict could be given, the whole character of the judgment is hypothetical, if *A* is *B*, *C* is *D*, but whether *A* ever will be *B*, is for ever beyond the range of human foresight. *Human knowledge can only decide what will happen when certain natural agencies combine or come together, but whether they ever will fulfil this condition it is impossible to predict.* We can safely assert that the insertion of a lighted match will always be followed by the explosion of a barrel of gunpowder, but when and where this may happen no effort of science can determine. No unconditional prediction therefore can be based on any degree of knowledge we may possess of the efficacy of given agents to produce given results. There is no law of collocation involved in Causality, on the contrary Causality would almost seem to necessitate a certain degree of contingency. The principle of Evolution would banish contingency from the universe.

21. Mr Stanley Jevons thinks it absurd to suppose that any kind of generality can be based on the evidence afforded by the observation of a single instance, and he

would be undoubtedly right if the essence of this single instance was not the Causal process realized by Experiment. Of course in the loose acceptation of Induction as the method of inferring general laws from repeated instances, the whole stress lies upon the repetition, and not on the Causality exhibited. The truth is that the Causal act has in itself an element of generality which enables it to dispense with any supposed aid accruing from frequency of occurrence. Causation is an objective generalization as valid in one act as in many. Kant would call the employment of the Method of Difference a deduction of the category of Causality. By this he would mean that by Experiment the subjective conception of Causation, which might have been a mere figment of thought, was realized as an objective, actual, operating activity, *an objective fact proved by experience to justify the subjective form.* Kant himself prefers to dwell rather on the deduction or proof of the objective reality of the category of identity. But his procedure would have been far more intelligible if he had chosen the category of Causality, of the objective validity of which the experimental Method of Difference is a complete proof on Kant's own principles. Schopenhauer rightly thinks that Kant's exposition of the category of Causality is the most substantial part of his system, and the notion of Causation justified and objectified in experience certainly relieves Kant from the suspicion of idealism with which he is often credited. It is true that a lump of sugar and a cup of tea are in their last analysis only groups of sense impressions or modifications of consciousness. But the causal process which results from combining the two can never be reduced to sheer subjectivity. We may ideally mingle the sugar in the tea, but we shall never succeed in generating a sensation of sweetness. The best antidote to a tendency to idealism is the contemplation of the Causal process, and with Kant himself Causality, Objectivity, and Reality, seem convertible terms.

22. Of Mr Mill's other Inductive methods, only those designated the Method of Concomitant Variations and the Method of Residues, rest upon any proof of direct Causation, that is upon the observation of a change wrought in response to the introduction of a new agency. Mr Mill thus describes the method of Concomitant Variations, "Whatever phenomenon varies in any manner whenever another phenomenon varies in some particular manner, is either a cause or an effect of that phenomenon, or is connected with it through some fact of causation." It is obvious here that every stage of variation may be regarded as the application of a fresh agency, and therefore all the reasoning founded upon the observation of change and causality in the Method of Difference can be equally employed in the process of Concomitant Variations. We infer that the fire is the cause of heat in a room because the nearer we approach it the hotter we feel, or the larger we make it the higher the temperature of the room, *but every increase in the degree of the intensity of the cause is practically the presentation of a fresh cause.* This method is naturally employed to discover the dependence of cause and effect in those cases where the Causal agent cannot be wholly detached from the sphere of activity of the group with which it is mingled. But although it cannot be entirely isolated or extinguished, the supposed agent may frequently be made to vary with assignable differences, and the corresponding

change in the effect being noted, their dependence is tested and verified.

23. The procedure in the Method of Residues is stated by Mr Mill as follows, "Subduct from any phenomenon such part as is known by previous inductions to be the effect of certain antecedents, and the residue of the phenomenon is the effect of the remaining antecedents." Suppose that we have the antecedents *A*, *B*, *C* followed by the consequents *a*, *b*, *c*, and that by previous inductions (founded we will suppose on the Method of Difference) we have ascertained the causes of some of these effects, or the effects of some of these causes; and are thence apprised that the effect of *A* is *a*, and that the effect of *B* is *b*. Subtracting the sum of these effects from the total phenomenon, there remains *c*, which now, without any fresh experiment, we may know to be the effect of *C*." We see here that as Mr Mill proceeds to observe "of the two instances which the Method of Difference requires—the one positive and the other negative, the negative one or that in which the given phenomenon is absent, is not the direct result of observation and experiment, but has been arrived at by deduction*." Mr Jevons gives a homely illustration of the employment of this method. We can ascertain the weight of a closed box of goods by direct experiment, and we know the weight of the empty case by a previous observation, hence we can infer the weight of the enclosed contents without having recourse to actual experiment. This method is not purely inductive because the whole process is not begun and ended in the compass of a present operation, there is an element of deduction contained in

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* Mill, Book III. chap. 8.

the procedure in so far as we depend on some knowledge acquired previously to the present experiment. It is especially to be noted that in pure induction based upon the Method of Difference *no tincture of previous knowledge is necessary as material of reasoning*, and it is this purity from anything but the given existing present phenomena that renders the Method of Difference the absolutely necessarily initiatory stage in the acquisition of all knowledge. When it is said that all human knowledge is based on experience, the more appropriate phrase would have been that all human knowledge is based on experiment by the Method of Difference. Every impression on the senses is an experiment where the agent whose activity is tested is some external cause termed an object. The aptitude of this object under similar conditions to manifest its activity on the sense organs in a similar manner constitutes our notion of the objective and external world, of which we have a direct apprehension through the Causality revealed in the acquisition of knowledge by experiment or experience. But as we have seen the very idea of causality itself although realized in experiment is necessary to the interpretation of experiment. Hence, if all knowledge is based upon experiment or experience of change, the conception of Causality must as Kant affirmed, be assumed in order that experience may be possible. Thus we can understand what is meant when Kant asserts that without the Categories experience would be impossible. Experience may be of two kinds, subjective and objective. Subjective Experience is the mere consciousness of the succession of our mental states. It is not this kind of experience which is really meant by those philosophers who maintain that all our knowledge is derived from experience. Subjective Experience is not and cannot be the material of knowledge of anything beyond itself. The experience upon which empirical philosophers found all knowledge is Objective Experience, that is, the apprehension of phenomena as modes of external being, not modes of our own consciousness, modes of *being*, but not of our *own being*. But how do we perceive that such supposed modes of being are not modes of our own being, how do we know that the phases of what we term objective existence are not mere subjective changes? This assurance is only given by a repeated exercise of the Method of Difference through the instrumentality of the sense organs. If a man wishes to convince himself of the objective origin of a visual impression, he has only to shut his eyes and observe whether the impression still remains. If it persists, it is a proof by the Method of Difference that the supposed impression is merely subjective, for an effect remains after the supposed cause has been removed, therefore the supposed cause cannot be the real cause. Objective experience then requires the category of Causality without which the Method of Difference cannot be interpreted. *The real foundation of objectivity is Causality exhibited in the momentary experiments which constitute the exercise of the senses.* Every act of the senses is an experiment by the Method of Difference involving a perception of Causal sequence, of which one term is an agency not ourselves, and the effect is a change in consciousness. That the one agent is something not ourselves we are forced to allow by this very conception of Causality which reveals itself in every experiment of the sense organs. It is by Causality only that we are able to transcend the sphere of the subjective, yet it is by experiment only that Causality is realized, hence it is by experiment or objective experience only that we become conscious of the category of Causality. Mr Mill derives this conception from the testimony of uncontradicted experience, of course he does not mean subjective experience, because as he writes somewhere in answer to Dr Whewell: A man when he puts a spade into the ground does not put the idea of the spade into the idea of the ground, but an objective spade into an objective ground. By experience therefore Mr Mill evidently means objective experience. But we see that no single act of objective experience is possible without an assumption of the principle, law, category, or conception of Causality. The expectation that every effect must have a cause, it is true arises instinctively in the child, the savage, and even the lower animals, and hence Mr Herbert Spencer has been induced to attribute this and many other of the Kantian Categories to the results of gradually accumulated inherited experience transmitted through infinite stages of development. This theory is fraught with difficulties, but with regard to the instinctive character of the notion of causation, it may be remarked that when agency is looked for by all conscious beings on the experience of change, there is not necessarily a developed sense of the distinction between subject and object. On the contrary it is more probable that the sense of the distinction between subject and object grows out of the perception of the correlation of change and agency.

24. We have seen that the Method of Difference or Experiment is available either in discovering the effect of a given agency, or the agency which is at work in the

production of a given effect. Or in other words by this method we may reason from cause to effect or from effect to cause: arguing from cause to effect is termed Synthesis or Combination, and from effect to cause Analysis or Separation. In the former case we add or introduce an agent which operates the change: in the latter case we withdraw or abstract something necessary to the maintenance of an effect. Both these processes however involve experiment where Causality is actually detected at work. This possibility of arguing from effect to cause by means of experiment must be carefully distinguished from the inference to cause from effect *without resorting to experiment.* This, as we have elsewhere remarked, is a kind of reasoning wholly inadmissible, owing to the possibility of what Mr Mill calls Plurality of Causes. There is, however, one class of cases in which a valid inference from effect to cause may be instituted without experiment. There is an important distinction in effects, which we believe most writers on Inductive Logic have hitherto overlooked, a distinction which we may mark by calling some dead, and some living effects. If a man finds a bag of gold buried in his garden, he naturally infers by the law of Causation, that some one has placed it there, but the agency whatever it was, need not be still in existence, need not be always present to perpetuate the effect, and in short is not necessary for its maintenance. Such an effect we should call a dead effect, and there are no purely inductive methods by which we can reason anything concerning the cause. By a living effect, however, we mean a change which is being wrought under our immediate observation, and the agency or cause of which must therefore be extant, present and active, as when a man feels a draught of cold air he is forced to regard the agency as present and active. Now we have seen that by Experiment the causes of living effects may be detected by removing the supposed cause, and watching for the occultation of the effect, as in the given example—shutting the window and discovering that the draught vanishes. Mr Mill, however, describes a process of reasoning by which in some cases the cause of a living effect may be detected without Experiment. This is where it is possible to show that out of a number of existing and present agencies supposed competent to produce the given result, all but one can be proved incompetent. Thus Newton proved that the Sun was the centre of force in the earth's orbit by showing that if the centre of force was at any other point but the Sun, the earth's orbit would be different to that which it is. This, Mr Mill says is equivalent to a proof of the Method of Difference*. The effect must have some cause present and operative: all other present and operating agencies would, it can be shown, produce an effect different to that which is actually existing, therefore they cannot be producing the observed result, but there must be some present cause in operation adequate to this end, hence it must be that cause which has not been excluded. This kind of argument is equivalent to the indirect method of reasoning so often adopted by Euclid. He wishes to prove that a centre of a circle must be in a certain line, he does not do this directly, but he shows it cannot be in any other, therefore it must be in the line to be proved.

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* Mill's *Logic*, Vol. II. ch. XIV.

LECTURE III.

METHOD OF AGREEMENT, AND JOINT METHOD OF AGREEMENT AND DIFFERENCE.

25. We have shown that the active property of a natural agent may be discovered by surprising the agent in the very crisis of displaying its Causal Efficiency. The evidence of the possession by the agent of this active property is its activity operating under our immediate observation. A thing is what it does, we see what it does and therefore we know what it is, no evidence can be clearer, no reasoning more cogent, no proof more conclusive. Such is the power of experiment as the initial process of all human knowledge. Causality which experiment reveals may thus be considered as the basis and condition of knowledge. Experiment is objective experience, hence we see the correlation of the conceptions expressed by the terms causality, experiment, objective experience, knowledge. Causality is revealed by experiment which is objective experience, whence proceeds all knowledge. The idea of causality whether instinctive, acquired or inherited, is the foundation of science. Causality manifests itself to the immediate observation in the first instance as an established union

or proximity of two phenomena which we call cause and effect. Hence the frequent conjunction of events or phenomena is thought to be valid evidence of their causal dependence; and when the beginning and end of the causal process cannot actually be confronted by the means of arbitrary experiment through the Method of Difference, the presence and operation of agency is proved by the observed concomitance and sequence of things. The methods by which Causality is in this manner inferred are those described by Mr Mill as the Method of Agreement, and the Joint Method of Agreement and Difference. By the direct Method of Difference we have seen that Causality is directly perceived. By the Method of Agreement, however, and Joint Method, Causality is not directly perceived but only inferred from a certain regularity, or uniformity of sequence, which when properly tested and sifted by the rules constituting these methods, affords a warrant for the assumption of Causality. By the Method of Difference then we observe a cause and infer a law, by the Method of Agreement we observe a law and infer a cause.

26. The methods of Agreement and Joint Method introduce us to a view of the procedure and objects of Inductive Logic entirely different to that which is implied in the Method of Difference. It will be convenient therefore before discussing these methods to investigate somewhat minutely in what this distinction of logical process consists. In the first place then we have in the Method of Difference as already indicated, Causality as the ground of an inductive conclusion, but such Causality is the inductive conclusion itself. On the other hand the evidence on which the inductive con-

clusion is based in the Method of Agreement and Joint Method is the number and variety of instances, whereas in the Method of Difference number and variety did not enter at all into the reasoning; thirdly, it may be questioned whether the discovery of Causality is really the ultimate aim of the inductive process exhibited in the Method of Agreement. The observed frequency of the union of events or phenomena is not only evidence of Causality, but to the ordinary understanding and in the daily affairs of life, such frequency of conjunction is usually taken as evidence of *absolute constancy* of conjunction, so that the presence of one term is made the warrant and ground of anticipation of another. The fisherman concerns himself little with the causal connexion between a full moon and high tide, but it is of the utmost moment to him to be able confidently to expect the one from the sight of the other, on the assumption that because the full moon has always been accompanied by a high tide it always will be. This is the kind of inductive generalization usually denominated the wisdom of experience, and in fact it is the highest degree of wisdom to which under ordinary circumstances the majority of mankind can aspire to attain. Under the normal conditions of human life a man finds himself subjected to the influence of a number of natural agencies which he cannot control or direct, he is however able by informing himself of the mode and order of their operation to take such precautionary measures that they may be made to minister to his necessities and enjoyments. The husbandman cannot hope to avert the tempest, or stay the seasons, but he may know that seed time and harvest are furthered or hindered by certain conditions of the weather, and his agricultural pursuits will be regulated by this knowledge. In these cases genuine experiment is impossible as a means of discovering or proving the connexion of cause and effect, of agency and change, and the only means available are the observation and registration of the concatenation of events and the sequences of phenomena. From these data more or less trustworthy generalizations may be established according to which sufficiently confident predictions may be hazarded. The ancient idea of the nature of Induction and Inductive Evidence seems to have always been that of a rule based upon observation of particulars as they were termed, and the validity of the rule depended on the number of instances from which it was gathered. "Art," says Aristotle*, comes into being "when out of many conceptions of experience, one universal opinion is evolved with respect to similar cases. For indeed to entertain the opinion that this particular remedy has been of service to Callias, while labouring under this particular disease, as well as to Socrates and so individually to many, this is an inference of experience, but that it has been conducive to the health of all such as have been defined according to one species, while labouring under this disease, as for instance to the phlegmatic, or the choleric, or those sick of a burning fever, this belongs to the province of art." So Milton writes in *Il Penseroso*,

> "Till old experience do attain
> To something like prophetic strain."

Here it is evident that prediction is supposed to arise from the quantity of observation on the presumption that, that which had oftenest occurred in a given relation would be most likely to recur in the same relation. It is probable that the precise ground for this confidence is not present to the consciousness of most of those who entertain it, but the scientific intellect must admit that it is only the causal connexion of phenomena which can form a basis for the so-called uniformity of nature, and that this belief in the uniformity of nature must presuppose the conception of causal necessity. The Method of Agreement and the Joint Method will therefore be the logical procedure of ascertaining causality where experiment is impossible. If causal connexion can be established, then the inferred generalization or law may be asserted under the same limiting conditions as those which we found to prohibit any absolute conclusion flowing from an employment of the Method of Difference. What the student has to guard against is the *popular* notion of inductive evidence, which the assertion of general propositions on the supposed warrant of observed frequency of conjunction is apt to engender.

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* Aristotle, Book 1. chap. 1. *Metaphysics*. McMahon's translation.

27. Mr Mill thus describes the Method of Agreement: "Let *A*, then, be an agent or cause, and let the object of our enquiry be to ascertain what are the effects of this cause. If we can either find, or produce, the agent *A* in such varieties of circumstances, that the different cases have no circumstance in common except *A*; then whatever effect we find to be produced in all our trials, is indicated as the effect of *A*. Suppose for example that *A* is tried along with *B* and *C* and that the effect is *a b c*; and suppose that *A* is next tried with *D* and *E*, but without *B* and *C*, and that the effect is *a d e*. Then we may reason thus: *b* and *c* are not

effects of *A*, for they were not produced by it in the second experiment; nor are *d* and *e*, for they were not produced in the first. Whatever is really the effect of *A* must have been produced in both instances; now this condition is fulfilled by no circumstance except *a*. The phenomenon *a* cannot have been the effect of *B* or *C*, since it was produced where they were not; nor of *D* or *E*, since it was produced where they were not. Therefore it is the effect of *A*. For example, let the antecedent *A* be the contact of an alkaline substance and an oil. This combination being tried under several varieties of circumstances, resembling each other in nothing else, the results agree in the production of a greasy and detersive or saponaceous substance; it is therefore concluded that the combination of an oil and an alkali causes the production of a soap."

28. In the above exposition of the Method of Agreement it is to be observed that Mr Mill treats this method as available for experiment, or the direct detection of Causality, and not merely as a means whereby from a multiplication of instances the existence of Causality may be inferred. Mr Mill's words are "if we can either *find* or *produce* the agent *A* in such variety of circumstances, &c. &c." Mr Mill therefore brackets "find or produce" as apparently equivalent alternatives, but according to our theory of induction, to find an agent, and to produce one in a variety of circumstances, are things separated by a whole diameter of difference. To produce an agent, as Mr Mill terms it, is we suppose to place it arbitrarily and under our direct surveillance in circumstances enabling us to study its behaviour. But this is exactly the process imposed by the Method

of Difference, and there is no advantage in having repeated batches of circumstances along with which to test the efficiency of the agent. By introducing the agent into the first set of circumstances the experimental proof is complete. All we tend to substantiate by varying the conditions is the non-dependence of *A* on the factors which are combined with it in the experiment, but this can be as easily effected by what we call the inverse process of the Method of Difference, whereby we can ascertain which of the extant conditions of a phenomenon are indispensable factors of its cause. That the combination of an oil and an alkali causes the production of a soap, was established by the appearance of *a* or the soap at the first application of *A* to *B C*; it is true it was not known whether *BC* had not something to do with it, but that might have been ascertained by abstracting *B* and *C* separately and observing whether *a* survived,—in fact this is what is really done when *A* is tried with *D* and *E*. It is more logical therefore not to treat the Method of Agreement as a method of experiment at all. It is essentially the logical means of arriving at the fact of causality on data furnished by *observation only*. Mill's description then would be not if we could "find or produce" but simply if we could *find*, and we believe from various subsequent remarks that Mr Mill leant really to this view of the proper object of the employment of the Method of Agreement. Mr Stanley Jevons gives a very felicitous illustration of the use of this method in what we consider its legitimate application.

Sir David Brewster wished if possible to discover the cause of the erubescence or reddish tinge observable in Mother-of-pearl. He took the impression of the pattern of a specimen of Mother-of-pearl on a variety of different substances, such as wax, wood, metal, &c., and noted that in all instances the reddishness was still apparent; the conclusion was therefore, that the peculiar shimmer must be causally connected with the special pattern of the Mother-of-pearl. It might have been at first surmised that the composition of the substance upon which it was found was connected with it, but this element was fairly eliminated by the various traits on different materials. This is a valid employment of the Method of Agreement and displays the kind of phenomena to which it is applicable, the inference to which it leads, and the evidence upon which the conclusion rests.

29. From the last example it will be seen that there is still a certain amount of experiment connected with the employment of the Method of Agreement, although it is not a distinctively experimental method. In the Method of Difference the experiment is directly made on the phenomenon or agency the nature of which we wish to test. In the Method of Agreement, on the other hand, the experimental element of the process consists in altering the circumstances under which the phenomenon is manifested, without any modification of the phenomenon itself; the evidence thus obtained is indirect, we do not ascertain immediately that certain antecedents and consequents are connected because they appear and disappear simultaneously, but we isolate the supposed cause and effect by eliminating successively all the possible agencies present which might have accounted for the effect to be analyzed into its causes in the above illustration. We should say that strictly speaking the Method of Agreement is only available in the discovery

of probable agencies, and it is a mode of investigation essentially subsidiary to the Method of Difference which is the final appeal, or as Bacon termed it the *Experimentum Crucis* of all enquiry into natural phenomena. There is another method of investigation which Mr Mill calls the joint Method of Agreement and Difference, which to some extent possesses the cogency of the Method of Difference, although the premisses upon which its reasoning is founded partake somewhat of the flexibility of the Method of Agreement. In the joint method we take a number of cases, as in the Method of Agreement, in which the phenomenon and its supposed cause are patent, the cases or instances being varied in every other possible circumstance. For distinctness we may specify this branch of the enquiry as *A*, which is so far the Method of Agreement pure and simple. But in connexion and correlation with this process we may also find a set of instances in which the phenomenon and its supposed cause are both alike absent. This we may call the second, or *B* branch of the process. The result of the evidence afforded by this positive and negative kind of data is when taken as a whole, something resembling in character that yielded by the employment of the Method of Difference. What is shown is the simultaneous presence and absence of the conjectured cause and effect, that is wherever or whenever the effect is present the supposed cause is present, and whenever or wherever the effect is absent the supposed cause is absent; the inference is that the two phenomena which are always present together and the two which are always absent together must be causally connected. We do not observe, however, the cause and effect actually in the act of vanishing or appearing, in which lays the peculiar strength of the Method of Difference. If we did so in any one instance we should have a perfect employment of the Method of Difference. Here the argument from frequency of conjunction is made to supply the want of that perception of the actual causal link which can alone be furnished by the Method of Difference.

30. Mr Mill in his exposition of the Inductive processes does not draw attention to a distinction which seems to us of vital moment, in respect to a difference involved in the nature and value of inductive evidence, viz. it is possible to note the successive states of the *same thing* at successive moments of time, under the influence of some observed agency, or we may note the results of a given agency by means of *different things*, the difference in the things being that one is subject to the influence of this agency and the other is not. Now Mr Mill always seems to treat this successive and contemporaneous evidence (if we may so distinguish them) on precisely the same footing, but it will be abundantly manifest from what has gone before that in our opinion successive and contemporaneous evidence are very widely separated. The observed successive states of the same phenomenon *alone* furnish direct, immediate, and positive evidence of the present and actual operation of causal efficiency;—because it is only possible to obtain or insure a continuity of being in the unbroken series of the self-same existence. The same thing at successive moments of time can only differ in the change then and there initiated. The case is, however, very different with two objects, phenomena, or sets of circumstances, one of which is exposed to the action of a certain agency, and

the other is not. There is no living process here exhibited, there is no continuity of being, no event in short. Event and change are the very essence of experiment, it is just that which constitutes the particular from which the universal is inferred, viz. the particular act of causality, but where there is no event, no change, the causal conception has really no place. It is in this respect that the joint Method of Agreement and Difference supplies a kind of evidence intermediate in value between what we have termed the data afforded by the successive and contemporaneous methods of Difference. This will be better shown by an illustration of the employment of this method. A gardener wishes to try the efficacy of a certain kind of substance which he has been assured is highly stimulating to vegetation, say nitrate of soda. He forthwith irrigates half a bed of plants with the solution of this mineral, leaving the other half to the unsophisticated influences of nature; in a few days he finds as the result of this experiment that the plants which have been watered with the nitrate of soda have shot up, expanded, and completely surpassed in every mode of growth those which had not been subjected to the same agency. There is no possibility of doubting on this evidence that the nitrate of soda was the cause of the exuberant vegetation of the one set of plants in comparison with the other. This is a complete application of the joint method, it is experimental to a certain degree, inasmuch as a given effect is produced by the arbitrary administration of a given agency, but the procedure lacks that element of pure experimentation which the creation of an event or continuous change only discernible in the transition of the same phenomenon from one state to another can furnish. We do not surprise one plant in the act of expanding under the fertilising agency of the chemical compound, nor do we even find two exactly similar, one of which is subject to its genial influence and the other not, but we have a multiplied experience of the positive and negative cases by which an undoubtedly strong presumption if not absolute conviction is engendered. Suppose we had applied the solution of nitrate of soda to the whole bed of plants, we should here have had a simple example of the employment of the Method of Agreement. Each plant would be a different set of circumstances, and the presence of the operation of the chemical agency and the consequent luxuriate vegetation would be the constant elements found conjoined in each instance. Here, however, we should be immediately confronted with one of the most characteristic imperfections of the evidence of causality afforded by the bare employment of the Method of Agreement. Although we might consider each plant as different in many of its conditions to every other, so that the variety demanded by the Method of Agreement would be satisfied, still it would have to be conceded that the chemical constituents of the soil throughout the entire area planted, supposing it was of moderate extent, would be the same. The climatic influences to which they were all exposed would be likewise the same. Hence the objection might be raised that possibly the abnormal development of the plants might be due to some special conditions of the soil or atmosphere to which they were subjected. This is always a flaw in the evidence furnished by the Method of Agreement, it is impossible to ensure complete variety in the manifold sets of circumstances amid which the agency and its result are studied, and if one common element is allowed surreptitiously to remain in every instance it may always be urged that this was the operating agency. If, however, we supplement the evidence derived from the affirmative employment of the Method of Agreement with corresponding sets of negative instances, that is to say, sets of circumstances comparate with the affirmative cases, but where the agency to be studied and its result are alike conspicuous by their absence, we are by this branch of the method exempted from the weakness of proof inevitable to the purely affirmative part; for supposing as in the illustration recited some common element is known to remain in all the varieties of circumstances under which the conjoined phenomena are observed, still this would not vitiate the process, for to take the concrete fact we adduced, viz. the similarity of the soil, this agency was present in all the negative instances, and yet did not produce the result under consideration, but if the cause is present the effect must be, therefore it is evident that any particular fertility of soil was not the stimulating agency in question. There may be still urged as an objection to this branch of the proof, that some neutralising agent may perhaps be operating in all the negative instances. But it is, however, assumed that every instance is varied so that the probability of a common neutralizing agency is diminished to an indefinite extent. So far we have illustrated the use of this method in connecting an observed effect with an assignable agency. We shall find it equally efficacious in the converse process of detecting the proximate cause of an assigned effect.

31. We shall again illustrate by a concrete example

the logical procedure observed in this method. A few years ago there was an outbreak of cholera in one of the poor crowded districts of London, and as the disease appeared at first restricted to a certain area, it was deemed highly probable that it must be due to some local cause, which if detected could be extinguished and the spread of the malady arrested. Enquiry led to the discovery that all the inhabitants of the district were in the habit of using water from the same well. This then was an agency which might be conjectured to have some connexion with the outbreak of the disease. This presumption was further strengthened by the fact that in an adjoining district the inhabitants were subject to all the conditions of life similar to those of the cholera-stricken area, with the exception they did not drink water from the same well. Hence it might be argued that the water was the cause of the disease, for if uncleanliness was urged as a possible agency, it might be shown that both districts were alike in this respect, and so with bad food, bad air, overcrowding and all the adjuncts of poverty, neither area was exempt from any of these, yet only one was afflicted with the disease, hence the single agency present in one and absent in the other must have been the cause. The hint was taken, an access to the tainted spring prevented. As soon as the means of distributing the germs of the disease were thus cut off, the disease itself in the suspected area vanished, and hence the cause was finally verified by a genuine employment of the Method of Difference. In the first illustration cited above, by which the process of finding results of a given agency was exhibited, it might still be asked why in administering the new agency in one instance the conditions of the Method of Difference were not rigorously fulfilled? the plant was exposed to a fertilising influence and forthwith manifested a corresponding development. But here is presented a difficulty with which the Method of Difference pure and simple is not competent to cope. How could we have been sure that the same vigour of growth would not have been realized without the assistance of the artificial manure, might not some inherent capacity or vital energy have produced the same result? In answer to this objection we have only to appeal to the negative instance, but the proof is not absolutely demonstrative, because the positive and negative parts of the process are not tried on the same subject. In living organisms the time element occupies such an important place that its presence constitutes a source of infirmity in the evidence which would not have otherwise existed. The metamorphosis or transition which the introduction of a spark into a barrel of gunpowder will operate is instantaneous, immediate and direct, offering scarcely any room for the quibble that some other agency may have surreptitiously insinuated itself. The longer the time however that must elapse between the inception and consummation of a process, the greater degree of weight would attach to this possibility, and as life processes cannot be manifested without considerable duration and many subsidiary functions, such as assimilation, absorption &c., it is obvious that the connexion between a supposed proximate agent and an observed change cannot be amenable to the evidence afforded by the direct application of the Method of Difference. The joint method is therefore an instrument of great efficacy in similar classes of phenomena. In daily life it is perhaps the most frequently employed of all the methods, although of course the grounds of its cogency are not generally considered. In Pathological Science it is necessarily the only method available. There are many minds to whom its evidence is the reverse of conclusive. We have only to instance the contemporary outcry in certain quarters against vaccination, as a prophylactic agency against small-pox.

32. We have thus delineated five principal methods by which the causal dependence of phenomena and the concatenation of events is ascertained. In the first three processes, this dependence is made the matter of direct observation, in the last two it is inferred on the warrant of observed frequency of conjunction, combined with the elimination of contemporary agents which are proved to be unconnected with the Cause or Effect to be investigated. There is one other class of data accepted as evidence of phenomenal dependence, which indeed is often roughly understood as the characteristic mode of Inductive reasoning. This is the kind of evidence which consists of simple reiterated conjunction of things or events which are thence believed to be associated through some necessity, law, or behest of nature. We have already shown that phenomena of coexistence, unless they can be converted into cases of succession, are only amenable to this sort of evidence.

LECTURE IV.

INDUCTION AND DEDUCTION.

33. EVERY one speaks in contrast of the two modes of rational procedure known as Induction and Deduction, yet many writers show special anxiety to prove that there is no real distinction between the processes. The attempted identification of Induction and Deduction is made from the side of either. On the one hand, Mr Mill and his followers maintain that the only kind of rational procedure is Induction, and to this Deduction is ultimately reducible. On the other hand, Jevons and other writers are concerned to insist that all valid inference is obtained from Deduction, and that the Inductive process is illusive, and only a disguised form of deduction. Between these conflicting modes of depicting the subject, students are apt to entertain a very confused notion of the real characteristics of the logical processes considered under either aspect. If Induction and Deduction are identical how have they come to be so broadly distinguished, and if they are radically separate how has it been possible to identify them? Are they two views of the same fact, or a perception of two distinct processes?

34. It is clear from Mill's treatment of the Inductive and Deductive methods of proving or investigating

phenomena, that he does not consider them as anything more than two stages of the same operation. Induction is according to this writer, the reasoning by which we attain the expectation or belief that certain characteristics of physical aggregates, or certain groupings, or order of events will be met with under certain conditions. The data upon which this surmise is based are what are termed facts, specific instances, or particulars which have been encountered or have happened within the experience of mankind, and Induction is simply the expectation with regard to the same class of things or events. A Deduction is the combination of our knowledge concerning various kinds of phenomena from which there results an expectation of something different to the components. What an infinite variety of inductions are blended in a complex physical science like Astronomy! Induction is the establishment of a single thread of human knowledge, Deduction is the weaving of many threads into a single fabric, but the ultimate material of the finished product is the same as that of each constituent fibre. This is the logic of Positivism which admits of no element in human knowledge but the facts of which the knowledge is conversant. In other words this school of writers allows no *à priori* tincture in human knowledge, no form to regulate the matter, no pattern to indicate a plan. From this point of view Induction is only the summation or embodiment of a multitude of past experiences which are taken as samples of the future, each Induction is a constituent part, a line in the page of the future, whereas the Deduction is the systematized whole or completed structure. Analysis reveals the Inductions which go to make up a complex deduction, and it is the business of science to untwist the strands which together make the parts of a composite whole. To illustrate the function of Induction and Deduction respectively, in the process of human reasoning, we might take a single example. Suppose for instance we say that the wind is west and therefore we may expect rain. This expectation might be grounded on a simple induction of experience that whenever the wind had been in the west there always had been rain, or it might be the resulting anticipation arising from the combination of several separate inductions. The west wind sweeps over the wide expanse of the Atlantic Ocean—this is a geographical induction. Again, in the course of its passage the westerly current of air becomes charged with a mass of aqueous vapour—this is another induction belonging to the realm of physical science. Finally, on entering a region refrigerated by the subjacent land, the atmosphere is condensed and its humid contents precipitated in the form of rain—this is a meteorological induction. If then we view the item of knowledge, that the west wind will be accompanied by rain, as a whole, we see that it is a totality made up of the three parts, just signalized as three separate inductions. Deduction then is the process of putting together the parts of knowledge to form a whole, a process which is termed by some writers Synthesis, in distinction to the converse process of dissecting a whole into its parts which is Analysis.

35. According to the above exposition of Mr Mill's use of the terms Induction and Deduction, we see that the two processes really differ with regard, (1) to their premisses, (2) to their conclusion. The premisses or data of an induction are isolated facts, the conclusion em-

bodies all the facts with the addition of an indefinite number of similar ones comprehended in the inductive sweep. The premisses of a deduction are not single facts, but the inductions including an entire group of similar phenomena, and the conclusion is a piece of knowledge narrower in scope or comprehending fewer phenomena than the premisses. This is obvious, since the range or sphere of one inductive premiss is limited by another, and the resulting inference is of less extent consequently. A good example of the deductive mode of combining inductions is furnished by the discovery of the inflammatory character of diamonds. It was known that refracting substances were combustible, which is an induction embodying a multitude of like facts, viz. the fact that a substance which refracted had also been constantly found to burn. Again, it was noticed that diamonds were highly refracting, hence it was inferred that the property generally possessed by refracting substances must belong to diamonds, or in other words that diamonds were apt to burn. This is a conclusion arrived at by deduction or the combination of two premisses, each one of which is an induction from particulars or single facts. The same conclusion would have been reached by the simple method of throwing a diamond on the fire and noting the result or repeating the experiment. We should then have the same piece of knowledge respecting the combustible property of diamonds but it would be an induction from particular instances or experiments. In the deductive proof no experiment was necessary, at any rate no experiment of the specific law to be established. We see also in this illustration how the conclusion is narrower than the premisses. Combustibility is predicated of all refracting substances in the premiss but is limited to diamonds in the conclusion.

36. It is hence evident that the same inference may be arrived at, by the two different methods of Induction and Deduction. Mr Mill shows how in sound scientific procedure the one method is used to verify and corroborate the other. If we have reached the law or generalization, that diamonds burn, by the deductive process, we can assure ourselves of its truth by throwing two or three diamonds on the fire. On the other hand, after a few such experiments we may clench the induction by deducing it from certain admitted premisses. The analysis of an inductive truth into its component premisses Mill calls Explanation, although in popular language this term is generally applied to the assignment of the causes of a given effect. Mill also includes under Explanation, the process of subsumption, or reducing different classes of phenomena to one more general group, as for example, Galvanism, Magnetism, Electricity were once considered distinct sets of phenomena, but they are now recognized as homogeneous. A simple induction founded on mere frequency of conjunction, and not tested by any of the inductive methods, Mr Mill calls an *empirical* law; he also terms those laws which are found to be complex, *derivative* laws; and if their components are proved to be laws of causation, they will be causal derivative laws. Thus, to revert to a former illustration, that the west wind brings rain, this statement in its first bare form resting on the evidence of repeated experience only, is the statement of an empirical law, subsequently the progress of human knowledge has enabled us to resolve this apparently simple empirical law into the three inductions

we have specified, each of which is susceptible of demonstration through the principle of causality. In the other example, the combustible character of refracting substances is also susceptible of causal verification by the Method of Difference.

37. In the above views of the contrasting functions of induction and deduction, we have adhered to the treatment of these processes adopted by the material school of logicians, of which Mill is the chief representative. According to their conception of the scope of logical doctrine, the distinction between induction and deduction which we have just expounded is consistent and intelligible, but to the school of formal logicians who hold that logic is only concerned with the form and not the matter of the reasoning process, the terms induction and deduction acquire a very different import. There cannot be two kinds of activity on the part of the reasoning faculty. The form of all ratiocination is the inference from whole to part, or Deduction, usually susceptible of being exhibited as the syllogism, of which one premiss at least must be a general statement. Reasoning from particulars to particulars is impossible from the point of view of the formal logicians, with whom the material of reasoning consists of concepts or general notions expressed and embodied in linguistic signs. *The rational faculty knows not particularity, its sphere is the universal.* A subjective language is an absurdity, the very essence of the sign is community of apprehension, and community of apprehension means generality of relation,—what is understood by the meaning of a word is its accepted significance to a plurality of minds, hence there could not be a language of particulars. Symbolism is universalism. The

reasoning process is solely conversant with the concatenation and interpretation of Signals, and Signals can never be particular in their import, they must appeal to a common consciousness, to a plurality of intelligencies. It may be objected that although Signals must be apprehensible by many minds, they may be still only indicative of a single object. The Eddystone light for instance may warn many mariners, although it is but the sign of a single object. So far, however, as it is a signal, it must be interpretable by all, and is therefore general in this sense. So language is a code of signals, the very essence of which is generality or community of interpretation. It is only proper names that are particular in their nature, and proper names do not really form any part of language. Proper names are not the signals or signs of any sense impressions, nor are they the expression of such impressions, they are merely an arbitrarily imposed mark interpretable by a limited number of individuals.

38. To the formal logician therefore Induction is only a term used to distinguish a certain variety of syllogistic reasoning generally known as the third figure, of which a common illustration is such an argument as The Ox, the Elk, the Deer, &c., are ruminant, the Ox, the Elk, the Deer, &c. are all horned animals, therefore all horned animals are ruminant. This is the inductive variety of the deductive method. Or again it is maintained that the material induction is only a formal deduction with a suppressed major premiss which states the so-called Uniformity of nature, that what is true of certain instances is true of all. In any case therefore the inductive procedure is resolved into a deduction, and the two

modes of inference are radically one, or at any rate are reducible to one.

39. It is easy to see how interminable may be the controversies which must arise respecting the functions of Induction and Deduction unless the point of view whence they are to be considered is previously defined. The formal logician may be perfectly justified from his point of view in rejecting the possibility of demonstrating anything through the instrumentality of particular facts only, without any generalizing or synthesizing element supplied by the mind; whence, every process of reasoning is deductive. On the other hand, the material logician regarding the manifold of particulars as the real data of cognition, justly refuses to admit the synthesized product as anything but a register of single instances, containing no more and no less than experience has put into it, and experience can certainly never generate the element of universality which deduction demands. It amounts then to assigning different meanings to the terms Induction and Deduction according to the stand-point of the formal or material logician.

40. The Inductive and Deductive Methods of science, which are so often contrasted, are of course distinctions applied to the procedures of estimating and correlating evidence, and therefore are functions of material logic. The Inductive Method is often used roughly to designate that kind of reasoning which rests upon the comparison of statistics furnished by History, especially numerical data and specific instances affording examples of frequency of conjunction which have to be relied upon for evidence when no better is attainable. Doubtless every science seeks at the present day to found its conclusions

on facts, and facts only,—and the results of every enquiry are looked upon with suspicion which appeal to anything like intuitive or *à priori* principles. The deductive method, however, as treated by Mill from the standpoint of pure empiricism need not of course involve an intuitive or *à priori* foundation.

The rival methods of Induction and Deduction appear sharply distinguished in the science of Political Economy, and constitute the distinguishing characteristic of the two schools of writers on this subject. The advocates of the Inductive method of which Ingram and Cliffe Leslie are the principal representatives, hold that Political Economy is not yet sufficiently advanced to allow of its leaving the safe ground of facts; while the writers of Mill's school maintain that certain leading principles are necessary to systematize and formulate economic laws. Such principles they say are axiomatic within certain limits, which are also the boundaries of the science itself. For example, Political Economy may safely assume that every man will strive for his own *maximum* advantage, since men not actuated by such a motive do not fall within the scope of the science. Hence a science may always rely upon principles which define the limits of the science itself. Geometry need not take into account the possibility of two straight lines enclosing a space, because such a phenomenon would be a subject for the consideration of some other science not Geometry. A science therefore need not delay its advance to await the absolute verification of its axioms, their truth is at least co-terminous with the science itself.

41. The term Induction is employed in Algebra in a somewhat technical signification. For example in

Newton's proof of the Binomial theorem. Here, although the method is called Induction, it bears very little analogy to the ordinary use of the term. If a certain law or order holds good generally, it must hold good in every particular case, but it can be proved to hold good generally, therefore it holds good particularly. If this is a correct description of Mathematical Induction, it would seem to be a process the exact converse of that which the term Induction is generally used to designate. In the ordinary procedure we certainly do not commence by proving anything of the general term. This is emphatically the distinguishing feature of Deduction. The only element of particularity in Mathematical Induction is the discovery of the form of the law from the observation of specific instances. But this is by no means the same thing as proving the truth of the law from specific instances. Those philosophers who hold to the purely empirical origin of all rational proof are confronted with a difficulty in the general term of mathematics, for which no empirical equivalent is possible, and which is yet the foundation of all valid demonstration. It was doubtless the perception of the necessary universality of geometrical and arithmetical reasoning that led the ancients to attach such a value to the deductive method to the extent of regarding it as a sole organon of truth. The induction which they alone knew, divorced as it was from experiment, offered no sort of equivalent to the understanding, and only through the teaching of Bacon was it shown, how to compensate in physical reasoning the want of a general term by the adoption of the principle of causality, and even now the real office of this principle in physical demonstration is scarcely recognized. It might surprise many to hear that the conception of causality is in physics what the general term is in mathematics, and yet it is abundantly manifest that both discharge the same function in the process of demonstration. Induction then simply will not prove anything, because the essence of proof is subsumption, which implies something more general than the thing subsumed. Kant took it for granted that the material of reasoning or the things which were reasoned about must be universals in the new sense which he gave to this term, viz. that universal subjectivity or phenomenality, which, with him, was equivalent to objectivity.

42. In contrasting the Inductive and Deductive Methods of any science what is generally meant, is, only whether we do or do not rely solely upon finite evidence in the form of arrays of facts not embodied or condensed in any general assertion. Mr Mill shows that no science can make any considerable progress as long as it is in the inductive stage, but it becomes a question to decide when a science can safely venture on the ocean of deduction. Besides Induction and Deduction, since Mr Mill wrote, the comparative or genetic method has assumed a very prominent place in the processes of human reasoning, and to many minds the conclusions arrived at by this method are equal in cogency to deductions. It is also sometimes called the historical method, and partakes of the nature of induction to the extent of depending upon bare facts for its material. The only *à priori* principle to which it appeals, is that known as the law of continuity, which serves like the principle of causality in experiment to interpret and give significance to facts. The sciences to which this method is applied are those in which experiment is impossible, especially Biology, Cosmology and

every branch of Natural Science. The leading conception of this method is that of insensible gradations. Natura facit nihil per saltum. All life and growth is a progress by infinitely minute imperceptible stages. This conception is partly mathematical, partly logical. It is a familiar artifice of thought in geometry to imagine a finite line as made up of an infinite number of infinitely small points, and Newton made extensive use of this method when he treated a continuous force as made up of an infinitive number of finite impulses. Some of the ancient logical tricks or Sophisms depended upon this principle, for example, the well-known puzzle of Achilles and the tortoise, which turned upon the fact that a finite space of time could be divided into an infinite number of infinitely small intervals, as we might prove with equal plausibility that the hand of a clock being at two would never reach three, because it would have to traverse an infinite number of points on the way, which would occupy an infinite length of time. This infinitesimal calculus applied to the phenomena of life and growth exercises a considerable fascination on the speculative intellect, and its conclusions in this domain do not admit of the *solvitur ambulando* method of refutation, so that they have the advantage of being able to keep the last word. Supposing a theory to be announced respecting the origin of some civil or religious institution, the method of insensible gradations would look about the habitable globe for examples of the given institution in every stage of development. Besides these contemporaneous instances, which are matters of strict observation, the method appeals to historical evidence, which can trace some existing phase in the life of a community from its primordial germ, and thus there are two lines of evidence at right angles to each other, as it were. If there is any link wanting in the series it is hypothetically supplied by the principle of continuity, hence the line is unbroken theoretically. If it is urged that the process can never be detected in actual operation, it may be retorted that a watched pot never boils, which is only the vulgar expression of the infinite divisibility of finite processes and the imperceptibility of each step.

43. The comparative method addresses itself chiefly to the acceptance of those who rest the verification of an hypothesis principally upon the harmony of facts with it, and the clue which it affords to the explanation of other facts not previously susceptible of analysis. The principle of continuity in phenomena of development is considered by Kant somewhat antagonistic to the principle of causality. The principle of causality is opposed really to the idea of change consequent upon the operation of immanent agency. But this latter is the central notion of growth or biological development, although the apparently automatic action of vital processes is conditioned by the assimilation of extraneous substances. Life and growth cannot proceed without food and nourishment. The plane of causality however, seems to cut that of continuity at right angles, and in fact we only apprehend them as complementary principles. The conception of immanence again seems to lead us to an extremely recondite idea of being, as involving potentiality and primordial tendencies of a nature too occult for any perception unaided by the highest degree of speculative faith. The physical microscope has opened a new creation to the scrutiny of the

human intellect so that "nature appears greatest in leasts." There may be, and some think there is, still another realm to conquer, where the scientific imagination finds the beginnings of being and birth of difference, so the activity of the human intellect is completing its cycle, and returning to metaphysics as a basis of positive science, after having pronounced the two to be irreconcileably antagonistic in method, matter and aim. Still the flights of human curiosity will not be restricted by the chilling fetters of positive logic. "Man is the hunter of truth," says Plato, and even if the chase does not end in the discovery of truth it may serve to unveil a falsehood, so that progress is still made. Mr Mill is rigorous in his demand that all hypotheses should be required ultimately to submit to the test of the Method of Difference. This would exclude all but experimental sciences from the range of human research. History is the world's memory and it cannot be consistent for the empirical school to discredit the reservoir of evidence which experience of the past has amassed, and upon which their whole method depends. But History can never be verified by experiment nor even by experience. History is a tissue of hypotheses never capable of either complete inductive or deductive proof. Yet, according to the empirics all induction and deduction rests upon such historical evidence.

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